IMPROVED SCIENCE TEACHING IN SCHOOLS

(A Report of the Experimental Programme in Science Education in India with special reference to the Summer Institute Programme of 1963 and the Conference of Education Secretaries held on July 29, 1963)

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PREFACE

The summer of 1963 witnessed a new programme introduced in country in the area of science education. This was the four summer institutes organized by the University Grants Commission, the National Council of Educational Research and Training and the United States Agency for International Development as a co-operative venture to improve science teaching at the secondary school level. Over the last seven years, the new experiment has been going on in the United States to develop improved new science materials in physics, chemistry, biology and mathematics with the help of a co-operative committee of university scientists, school teachers and educators These materials represent a tremendous investment in terms of time of scientists and educators to remove the obsolescence from science instruction in schools, and to make it vital. The committee which developed these materials in the U.S A. had approximately equal numbers of university scientists and secondary school teachers The book on Physics brought out by Physical Science Study Committee is an illustration of the type of work carried out by these workers. Along with the textbooks have also been developed teachers guides, students manuals, experimental kits and supplementary material The National Council of Educational Research and Training has already reprinted the book, *Physics* as a cheap edition to bring it within the reach of the ordinary school teacher in India The Teachers Resource Books (in four volumes) and the Students Laboratory Guide accompanying this book are also being reprinted and are expected to be available to science teachers very shortly.

These new materials developed with such investment of time and effort indicate a new revolution in science teaching and learning. With the growth of scientific knowledge at a tremendous pace and the growing dependence of a country's welfare on its scientific and technological progress, it has become exceedingly important to inject new life into the science instruction in our schools and to raise it to a standard commensurate with the new technological age. It is obviously impossible to impart to the young the load of information that scientific discoveries are unfolding; what is essential is to give the student the basic and fundamental knowledge and skills which will inculcate the scientific attitude and the capacity to delve deeper into science.

The Council has been engaging itself during the past two years in several significant programmes to improve science education at all levels of school education. The major focus in any programme of educational improvement is the teacher and this applies with increased emphasis to the science teacher Therefore, in any venture to usher in a new area of science education in our schools, it becomes imperative to orient the science teacher to new materials and approaches. During this summer, therefore, in collaboration with the University Grants Commission and the US AID, the Council undertook to organize four summer institutes in selected universities of India, one for each of the subjects, physics, chemistry, biology and mathematics, to acquaint the teacher with the new programmes developed in the USA and to see to what extent they could be used in our school. The US AID gave technical assistance in the form of visiting American Consultants who had been associated with the various Study Groups They also provided books, experimental kits and films. The enthusiasm with which the new approaches and materials were received by the participants of the institutes indicate how much of the content, new methods of enquiry and new methods of evaluation used in these programmes could well be incorporated in our own secondary school programme.

Since the success of any new educational programme depends upon the measure in which it is received by the State Departments of Education, it was considered desirable to utilize the presence of State Education Secretaries at New Delhi in the last week of June to discuss this new experiment of Summer Institutes and their significance for the future of science education in the country. Therefore, a session was kept apart on the 29th of June, 1963, for discussing the subject. The Directors of the four Institutes and the visiting American Consultants were invited to participate. Dr. D. S. Kothari, Chairman, University Grants Commission, who has always evinced great interest in science education at all levels, was kind enough to participate in the day's discussions and give his valuable suggestions on the further steps to be taken to improve science education in the schools.

The Directors of the Institutes and the visiting scientists presented a first-hand report of the programme as tried out in the Institutes, their assessment of the Institutes, the materials used and their suggestions for further measures. Working papers were distributed to the participants and much of the material in these working papers has been incorporated in Parts I and II of this report. Books and selected experimental kits used in the Institutes were displayed at the time of the session The PSSC's publication *Physics* which had been reprinted by the Council and the all-India General Science Syllabus recently brought out by the Council were on sale The Combined Book Exhibition of science books received as gift by the National Council of Educational Research and Training from the Asia Foundation was also on display

It is now proposed to expand the programme of Summer Institutes to a large number of universities next year, so that more teachers may participate and benefit by the experience. Panels of scientists appointed by the National Council are already working on developing new science books on physics, chemistry, biology, and mathematics. These books and the syllabii on which they are based will have to be brought to the notice of science teachers in our schools. The Council in collaboration with the University Grants Commission is, therefore, proposing to expand this programme of Summer Institutes in gradually increasing numbers until it is hoped that, at a not too distant date, summer courses for science teachers will become an accepted programme in almost every university. In no other way is it possible to keep our science teachers sharpened to the latest advancement in science and methods of science teaching.

This report has been compiled in the hope that the significant features of this new experiment will be brought to the notice of those interested in the improvement of science in the country. It will also provide material in organizing future Summer Institutes. The report is divided into four parts. Part one gives an account of the studies carried out in the USA to develop the new materials in physics, chemistry, biology and mathematics The second part deals with the Summer Institute programme of 1963 conducted in India The report of each Institute by its Director is followed by an evaluation of the Institute by the Coordinating Committee, the visiting scientist and the participants. Part three gives a resume of the Conference of Education Secretaries who discussed this programme. In part four are appended reference materials used in these Institutes and the names of participants of the four Institutes.

Dr. Kothari in his remarks to the conference suggested that selected schools should be released from the rigidity of the examination system and a frozen curriculum in order to enable them to try new experimental approaches and new materials. The Education Secretaries welcomed this idea. Without such an experimental attitude it is almost impossible to cut new ground in educational method. We are confident that the enthusiasm generated by this year's programme will be augmented and maintained by further efforts in the future.

RAJA ROY SINGH
Joint Director
NCERT

New Delhi
August 1, 1963

PART ONE

NEW CURRICULA IN SCIENCE EDUCATION

1

THE CURRENT REVOLUTION IN SCIENCE TEACHING IN AMERICA

N. E. BINGHAM*

The Scientific Revolution

The scientific revolution, which has been going on for some 300 years at an ever accelerating pace, has within the past few decades moved at such a staggering rate that a revolution in science teaching became inevitable. The world's fund of tested knowledge has been increasing so rapidly, that without the means of keeping up to date, a science teacher would, in a few years, become noticeably out of date, and in a decade or so his fund of knowledge could become completely obsolete. As Robert Oppenheimer has said, most of what is now known was not in any book when most of us were in school. A consequence of this rapid obsolescence is that any science teacher who is worth his salt has to be continually studying, and what he teaches changes markedly from year to year.

Science Teaching in the Twenties and Thirties

As early as the nineteen-twenties, science educators became aware of the rapid expansion of knowledge. General science and general biology were introduced into the schools in place of the more specific disciplines in an effort to make all students aware of the nature and extent of science, and to give them experience, at an introductory level, working the way a scientist works. Problem situations were designed to make the students speculate regarding their solution and plan laboratory activities to test these speculations. Efforts were made to habituate the approach of science in the solution of problems of the natural sciences, particularly, those that ramify widely in human welfare. The general education approach to the teaching of the sciences was extended to the beginning college programme and is even today the basis for many of the courses in the physical sciences and in the biological sciences offered to college freshmen and sophomores

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Expansion of Textbooks

Perhaps in a losing effort to keep up with the expanding fronts of science, the general science and biology textbooks, and also the physics and chemistry textbooks became thicker and thicker. More and more of the findings and the applications of science were included and less and less of the approach of science As the years went by, these high school texts consisted increasingly of unqualified, positive, expository statements of facts, which facts were to be memorized. Also, recognizing the need of everyone for science, the content tended to be chosen in terms of the use the learner could make of the facts to be learned—for example, the science books became filled with all kinds of practical applications of science related to industry, agriculture, transportation, gadgets in the home, and the control of pests and diseases

Similarly, the tests used to evaluate a student's mastery of his work tended more and more to test the memorization of facts, the new vocabulary, and the applications of science rather than any understanding of how the facts were determined, or to what extent these facts are valid.

But these frantic efforts were of little avail, for the fronts of scientific knowledge continued to expand at an ever increasing rate, and information memorized without understanding was quickly forgotten.

Understanding of How Facts Are Acquired

Memorized facts, often unrelated to an understanding of the procedures by which they were obtained, are of little value in new situations. For a student to effectively use facts in interpreting the everyday happenings of life, or in moving toward a higher level of understanding, he must know and appreciate how these facts originated.

Time for a Revolution in Science Teaching

Obviously, a revolution in science teaching was in order. That revolution has come and we are right now in the middle of it.

The new programmes will be taught so that students may live as scientists while gaining first an intuitive grasp, and later a more precise grasp of the basic pattern or structure of the sciences they are studying. They will use the laboratory to an increasing extent and much of what they will do in the laboratory will be investigatory rather than just illustrative in nature Emphasis will be placed upon thinking rather than upon the memorization of conclusions Students will be tested, among other things, upon a discernment of the doubts and incompleteness of science as well as upon the established facts, upon the hypothetical nature of conclusions, upon the interpretation of experimental results, upon the ability to formulate hypotheses to account for observations and upon the ability to devise experiments to test the validity of hypotheses

Development of the New Programmes

The development of materials in each of the new programmes was a cooperative effort in which University professors and top-flight scientists worked closely with top-flight science teachers. Writing was a joint venture Scientists and science teachers sat around a conference table and together planned what materials were needed and how these materials should be prepared The scientists did most of the actual writing, but in every case these materials were carefully read and criticized by the science teachers In most cases, the original draft was worked over several times.

Then these materials were tried out in the schools under the guidance of the science teachers who helped develop them. Changes were made in the light of the success in the classroom The materials written in each programme went through from three to four revisions in the light of experience gained with many thousands of high school students. The programme effectively combined development and research.

As the materials were tried with an increasing number of students, teachers had to be trained to use the new materials. Summer Institutes were organized—science teachers came to these institutes, studied the new materials and approaches, did the laboratory work that the students would be doing. They learned how to conduct an investigatory laboratory. They learned of the new developments in their particular science. They learned to teach science by themselves living as scientists. In this way they learned to teach science by having their students act as scientists.

The new programmes have gone through a rapid developmental stage As a result what is being taught in the science classes in America has been up-dated from thirty to fifty years High school students are now aware of what it is that scientists are now doing

Provision has been made to rework these programmes about every three years In this way what is taught in the schools will be in line with what is currently happening.

2

THE PHYSICAL SCIENCE STUDY COMMITTEE PROGRAMME IN PHYSICS*

The PSSC Course

The PSSC course consists of four closely interconnected parts. Part I is a general introduction to the fundamental physical notions of time, space, and matter: how we grasp and how we measure them. As the student learns of the almost boundless range of dimensions from the immensely large to the infinitesimally small, from microseconds to billions of years, he finds out how these magnitudes can be measured. He learns that instruments serve as an extension of his senses. Laboratory experience shows how we first measure by direct counting and then extend our range of measurements by calibrating and using simple instruments such as stroboscopes or range finders.

From these experiments measuring time and space, the student moves to an understanding of velocity and acceleration, of vectors and of relative motion. He then goes on to study matter, which we see moving through space in the course of time. In this first examination of matter, we develop the concepts of mass and of its conservation. We then use the evidence of physicists and chemists to find that matter is made of relatively few kinds of atoms. Direct experience is provided in the laboratory. There, for instance, the students compute the size of a molecule from measurements of thin films of oil. Moving pictures extend this direct laboratory experience by showing experiments which are beyond the reach of students.

Throughout, the student is led to realize that physics is a single subject of study. In particular, time, space, and matter cannot be separated. Furthermore, he sees that physics is a developing subject, and that this development is the imaginative work of men and women like him.

The topics in the PSSC course are selected and ordered to progress from the simple and familiar to the more subtle ideas of modern atomic physics. In Part I we have looked at a broad picture of the universe. Now as we examine certain fields of physics in more detail, we start in Part II with light. We live by light, and the student moves easily into the study of sharp and diffuse shadows, reflection in mirrors, and the refraction of light at optical boundaries. The natural development of the subject leads us to develop a particle theory (or model) of light Its discussion illustrates repeatedly the manner in which virtually all scientific knowledge develops Again, films—for instance, the film on the pressure of light—help the student to go beyond the laboratory

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* Excerpts from preface to the PSSC textbook.

Under continued scrutiny the particle model proves inadequate, and the student finds that we need another model—a wave model. The laboratory again provides an unexcelled source of experience, and here the student becomes familiar with the properties of waves He observes the behaviour of waves on ropes and on the surface of water. He begins to recognize the group of characteristics that constitute wave behaviour Knowledge of interference and diffraction comes directly from a study of wave in a ripple tank For the first time, perhaps the smears of light around street lamps, the colours of oil slicks, and the formation of images by lenses appear as aspects of the wave nature of light

During the first half of the course, the principal emphasis is on the kinematics of our world, where things are, how big they are, and how they move, not why. In Part III we turn to a closer look at motion, this time from a dynamical point of view. With simple laboratory apparatus, the students discover Newton's laws of motion. They learn to predict motions when forces are known and to determine forces when motions are known Thus armed they follow the extraordinary story of the discovery of universal gravitation, Newton's educated guess with which he jumped from the known laws of motion to the law of gravitational attraction

The laws of conservation of momentum and of energy are introduced through a combination of theory and laboratory exploration These laws form a substantial portion of Part III, and we stress their use in situations where detailed observation of the motion is not possible, as in Chadwick's discovery of the neutron and in the kinetic theory of gases

Part IV introduces the student to electricity and through it to the physics of the atom. Here the student uses the knowledge of dynamics gained in Part III. We begin with qualitative observations, then proceed to a quantitative study of the forces between charges. We learn how to measure very small electric forces and discover that electric charge comes in natural units We then study the motion of charged particles in electric fields and learn how to determine the masses of electrons and protons.

Next comes a discussion of magnetic fields produced by magnets and currents, and a discussion of the forces they exert on moving charges As a final part of electricity we discuss the induction laws and give the student a qualitative feeling for the electromagnetic nature of light Many of the fundamental ideas are explored in the laboratory—Coulomb's law, the magnetic field around a current, the force exerted by a magnetic field on a current-carrying wire are examples

Now the knowledge gained is used on a large scale to probe the structure of atoms Following the work of Rutherford, a nuclear model of the atom is established But some questions are unanswered Why, for example, is such an atom stable? Why doesn't it collapse by emitting light? In searching for the answer, we discover that light is both grainy and wavy Furthermore, it is found that although matter bahaves like particles in some respect, it also behaves like waves By combining both properties, we can understand the hydrogen atom and the structure of its energy levels In this part of the course, because direct experimentation becomes harder and more expensive, films bring to the student such experiments as the Millikan experiment and the interference of photons. At the end of the course we have arrived at a modern model of atoms.

Laboratory Apparatus and Films

It was initially the intention of the PSSC to develop laboratory apparatus which might be constructed by the student from materials which were generally available at his school shop or at home Upon trial, however, it was discovered that the savings in money did not compensate for the additional burden this cast upon the teacher Apparatus is now manufactured commercially and supplied in kit form, the primary task of the PSSC was to provide designs which made it possible to set the price at a minimum.

The PSSC films are part of a complex which includes the text and the laboratory. They bear little resemblance to other physics films used in the secondary schools. Each PSSC film presumes to some degree a knowledge of what has been presented earlier in the course, and is intended in part to open these specified areas which the student will later traverse. Most PSSC films include an experiment which cannot be done in the school laboratory or demonstrated in the classroom. In others, an attempt is made to present an experiment carried out with relatively simple materials, and within the capacity of an earnest student to duplicate. Some films summarize and integrate a topic by presenting several experiments or phenomena which could not be assembled by the teacher. Finally, certain difficult portions of the course are presented on film in the belief that the student will be best served if all the learning tools—the text, the laboratory, and the classroom discussion and the film—converge on the topic.

Most of the films are of use in any physics course, but their best and most efficient use is within the context of the PSSC course.

PSSC Physics

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2 Time and Measurement
3 Space and Its Measures
4 Functions and Scaling
5 Motion Along a Path
6 Vectors
7 Mass, Elements, and Atoms
8 Atoms and Molecules
9 The Nature of a Gas
10 Measurement

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11 How Light Behaves
12 Reflection and Images
13 Refraction
14 Lenses and Optical Instruments
15 The Particle Model of Light
16 Introduction to Waves
17 Waves and Light
18 Interference
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20 Newton's Laws of Motion

21 Motion at the Earth's Surface
22 Universal Gravitation and the Solar System
23 Momentum and the Conservation of Momentum
24 Work and Kinetic Energy
25 Potential Energy
26 Heat, Molecular Motion, and the Conservation of Energy

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28 Coulomb's Law and the Elementary Electric Charge
29 Energy and Motion of Charges in Electric Fields
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31 Electromagnetic Induction and Electromagnetic Waves
32 Exploring an Atom
33 Photons and Matter Waves
34 Quantum Systems and the Structure of Atoms

Tools of Learning

1. A new textbook.
2. A new laboratory guide
3. Simplified, low-cost apparatus in kit form
4. A set of 54 films which augments the laboratory, summarizes and integrates the various fields of study, and sets the tone and standards for the course.
5. Achievement tests designed to stimulate the application of knowledge and techniques to new situations and problems.
6. An extensive library of paper-bound books (Science Study Series) written by distinguished authors on the most stirring and fundamental topics of science
7. Teacher's guides which provide background material, make concrete suggestions for class and laboratory activities, and discuss critical sections of the course at the teacher's level.

PSSC Laboratory Experiments

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3

THE SCHOOL MATHEMATICS STUDY PROGRAMME IN MATHEMATICS

Since 1958, the School Mathematics Study Group has concerned itself with the improvement of teaching of mathematics in the schools of the United States The National Science Foundation has provided substantial funds in support of this endeavour One of the prerequisites for the improvement of teaching of mathematics is an improved curriculum—one which takes account of the increasing use of mathematics and science in technology and in other areas of knowledge, and at the same time, reflects recent advances in mathematics itself

One of the first projects undertaken by SMSG was to enlist a group of outstanding mathematicians and mathematics teachers to prepare a series of textbooks which would illustrate such an improved curriculum. It is not intended that these books should be regarded as the only way of presenting good mathematics to students at this level. Instead, they should be thought of as samples of the kind of improved curriculum that is needed and as sources of suggestions for authors of commercial textbooks.

How the Texts are Prepared

SMSG includes college and university mathematicians, teachers of mathematics at all levels, experts in education and psychology, and representatives of science and technology. Each summer since 1958, some of these individuals have gathered together on writing teams to produce text materials. In each case, the material generated by the writing team during the summer months was prepared for photo offset process, for use by schools during the following academic year, allowing the printer in some cases no more than a month to transform typed manuscript into paper-bound books Each of the texts passes through three identifiable editions: 'Preliminary Edition,' 'Revised Edition' and 'Sample Text Edition '

The School Mathematics Study Group prepared text materials in mathematics for use in the elementary schools, in the junior high schools, and in the senior high schools They also prepared special units of work, a library of mathematics reference books, and carried on and reported several research studies.

One can gain an idea of the new mathematics developed in algebra and geometry by examining the foreward and table of contents for each of these series of texts. These are reproduced in the following pages.

Introduction to Algebra

FOREWORD

The increasing contribution of mathematics to the culture of the modern world, as well as its importance as a vital part of scientific and humanistic education, has made it essential that the mathematics in our schools be both well selected and well taught.

With this in mind, the various mathematical organisations in the United States cooperated in the formation of the School Mathematics Study Group (SMSG) SMSG includes college and university mathematicians, teachers of mathematics at all levels, experts in education, and representatives of science and technology. The general objective of SMSG is the improvement of the teaching of mathematics in the schools of this country The National Science Foundation has provided substantial funds for the support of this endeavour

One of the prerequisites for the improvement of the teaching of mathematics in our schools is an improved curriculum—one which takes account of the increasing use of mathematics in science and technology and in other areas of knowledge and at the same time one which reflects recent advances in mathematics itself One of the first projects undertaken by SMSG was to enlist a group of outstanding mathematicians and mathematics teachers to prepare a series of textbooks which would illustrate such an improved curriculum

The professional mathematicians in SMSG believe that the mathematics presented in this text is valuable for all well-educated citizens in our society to know and that it is important for the pre-college student to learn in preparation for advanced work in the field. At the same time, teachers in SMSG believe that it is presented in such a form that it can be readily grasped by students.

In most instances the material will have a familiar note, but the presentation and the point of view will be different. Some material will be entirely new to the traditional curriculum. This is as it should be, for mathematics is a living and an evergrowing subject, and not a dead and frozen product of antiquity. This healthy fusion of the old and the new should lead students to a better understanding of the basic concepts and structure of mathematics and provide a firmer foundation for understanding and use of mathematics in a scientific society.

It is not intended that this book be regarded as the only definitive way of presenting good mathematics to students at this level. Instead, it should be thought of as a sample of the kind of improved curriculum that we need and as a source of suggestions for the authors of commercial textbooks. It is sincerely hoped that these texts will lead the way toward inspiring a more meaningful teaching of Mathematics, the queen and servant of the sciences

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Geometry with Coordinates

PREFACE

Formal geometry is usually introduced in a year-long course, often taught in the tenth grade *Geometry with Coordinates* is designed for such an introductory course, and contains most of the material of geometry which has been found appropriate for a course at this level The presentation here has one principal feature of novelty—it relies more heavily on algebra than has been common in a first course in formal geometry.

Such a fusing of geometry with algebra is characteristic of the development of mathematics, in which boundary lines among branches of the subject become blurred and eventually erased. Moreover, the relationship between geometry and algebra has recently been emphasized in the SMSG text Geometry, where Birkhoff's postulates, which make reference to the real numbers, are exploited. This book carries on in the same spirit, making explicit use of coordinate methods to obtain geometrical results

It should be noted that the reader is not required to have much facility in algebra to understand this book. It is expected that classes using this text will have had one year of algebra, and that the geometry course will provide an opportunity for students to review, consolidate, and extend their knowledge of algebra.

The primary emphasis in this treatment remains on geometry as a deductive system. It is hoped that our presentation will help to make clear that analytic geometry fits into this deductive system—that it is not just a set of recipes for solving problems, but is also a portion of mathematics, having its place in the organic structure which mathematics is today.

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THE BIOLOGICAL SCIENCE CURRICULUM STUDY PROGRAMME IN BIOLOGY*

The BSCS has developed three sets of course materials for a first high school biology course, BSCS High School Biology, including new texts, laboratory manuals, teacher's guides and handbook, laboratory techniques films and single concept films. Each of the Versions—the Blue, Yellow and Green Versions of BSCS Biology—provides a balanced presentation of biology suitable for use with classes in the average American high school, and within the intellectual capacity of most high school students.

The preliminary experimental edition of BSCS High School Biology was prepared during the BSCS 1960 Summer Writing Conference by teams of writers—70 high school biology teachers and research biologists. During 1960-61, 118 teachers tried out these materials with 14,000 students.

Based on this classroom experience and on reviews by eminent biologists, educators and psychologists, the 1961 Second Summer Writing Conference prepared a revised experimental edition of BSCS High School Biology. During 1961-62, this revised edition was used experimentally by over 500 teachers with 50,000 students

The final revision of these materials was prepared during Summer and Fall 1962. *BSCS High School Biology, Blue*, *Green* and *Yellow* Versions will be available through commercial publishers for general classroom use in the Fall of 1963.**

The BSCS programme is a general high school programme representing a genuine cooperative approach between significant teams of research biologists, high school biology teachers and other education specialists. It does not represent a revision, but rather a new start, based on the most up-to-date thinking in the field of biology.

BSCS Biology puts a greater stress on laboratory work; teachers report spending more than double the class time in the laboratory than they had with traditional materials. Furthermore, the traditional illustrative type of laboratory exercise is de-emphasized and stress is given to investigative exercises which introduce the students to the inquiring processes of science. All three versions have unifying threads—

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*For a complete list of materials developed in the BSCS programme, see Appendix B

**These are now available. —Ed.

nine basic emphases—that are woven in and through each of the three versions These are:

change of living things through time—evolution
diversity of type and unity of pattern of living things
genetic continuity of life
complementarity of organisms and environment
biological roots of behaviour
complementarity of structure and function
regulation and hoemostasis the maintenance of life in the face of change
science as inquiry
intellectual history of biological concepts

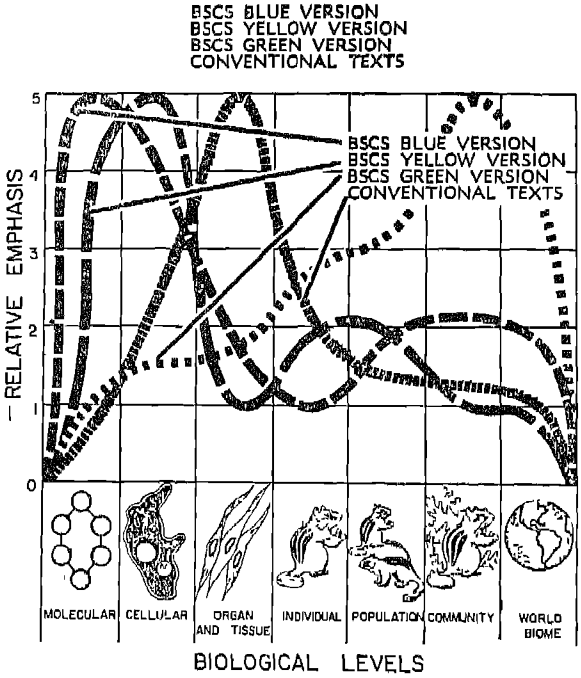
The theme, science as inquiry, concerns the materials and means by which content is presented in the BSCS materials. Instead of presenting the findings of science in a well organized series of unqualified, expository positive statements, materials are presented so that the student knows the problem of the scientists, the experiments performed in seeking a solution, and the interpretations of the data which produced the conclusions. Students will come to recognize the doubts and incompleteness of science, the possibility of advance through enquiry, and that scientific knowledge does change. Three approaches are made in achieving this aim, namely

1. A forthright expression of uncertainty where uncertainty exists
2. Current views are developed by a description of the experiments performed and the data obtained and interpretations made of the data
3. Laboratory work is in many cases investigative rather than illustrative

How do the three versions differ from each other?

While all versions are complete, year-long courses suitable for use at the tenth-grade level, there is a difference in emphasis in each of the versions of BSCS Biology (see chart at p 29) Traditional high school biology books give highest emphasis to the organ and tissue level in biology in BSCS Biology Blue Version, the greatest emphasis is on the molecular level of biology; in the Yellow Version, the major emphasis is on the cellular level of biology; and in the Green Version, the major emphasis is on the community and world biome.

It is felt that the emphasis in each of the three versions of BSCS Biology reflects the new developments in the field of biological knowledge over the past three or four decades, along with the process of inquiry which has led to this knowledge The differences among the three versions are not related to level of student achievement and it is estimated that the core content is about 70 per cent common among all three versions



Level of Emphasis in BSCS Biology and Conventional Texts

The BSCS is also concerned with—

Teacher Preparation to better prepare teachers for using the new biology materials

The *Special Student* to give optimal learning opportunities to students at both ends of the ability scale. Special materials are being prepared to help teachers work with the potential biologist and also with the under-achiever.

Special Laboratory Experiences to give the student an experience in depth in laboratory work through the use of one of a series of 6-week laboratory blocks to supplement BSCS Biology.

The Advanced High School Biology Course to provide a second-level high school biology course which will give a richer science experience.

International Cooperation to adapt BSCS Biology for use in other countries. Cooperative arrangements have been developed with several overseas countries interested in adapting BSCS materials for their own use.

Revised BSCS Yellow Version

CONTENTS*

Section A. Cells

Chapter 1. The Study of Life
Chapter 2. The Cell Theory
Chapter 3. The Theory of Spontaneous Generation
Chapter 4. Varieties of Cells
Chapter 5. Tools for the Study of Cells. Chemistry and the Electron Microscope
Chapter 6. The Physiology of Cells
Chapter 7. The Reproduction of Cells

Section B. Microbes

Chapter 8. The kinds of Microbes
Chapter 9. The Growth of Microbes
Chapter 10. Microbes and Man
Chapter 11. Microbes and Disease.

Section C. Animal Life

Chapter 12. Animals and Plants—An Introduction
Chapter 13. The Animal Way of Life
Chapter 14. The Diversity of Animals
Chapter 15. Digestion in Multicellular Animals
Chapter 16. Transportation and Respiration in Multicellular Animals
Chapter 17. Excretion in Multicellular Animals
Chapter 18. Coordination in Multicellular Animals
Chapter 19. Animal Support and Locomotion
Chapter 20. Reproduction in Animals

Section D. Plant Life

Chapter 21. Green Plants—Links Between Two Worlds
Chapter 22. Photosynthesis—The Strategy

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*The Contents have undergone some modifications in the final text. —Ed.

Chapter 23 Support and Conduction in Stems
Chapter 24 Roots—Anchorage, Absorption, and Conduction
Chapter 25 Movement and Storage of Materials Within the Plant
Chapter 26. Reproduction in Plants
Chapter 27 Growth and Development in Plants
Chapter 28 The Diversity of Plants
Chapter 29 Man and the Balance of Nature

Section E. Development

Chapter 30 The Development of Animals
Chapter 31 The Analysis of Development
Chapter 32 Development in Plants

Section F. Genetics

Chapter 33. Patterns of Heredity
Chapter 34 The Chromosome Theory of Heredity
Chapter 35 Genes and How they Act
Chapter 36. Genes in Populations

Section G Evolution

Chapter 37. Darwinian Evolution
Chapter 38 The Mechanisms of Evolution
Chapter 39. The Origin and History of Life
Chapter 40. The Evolution of Man
Chapter 41. The Cultural Evolution of Man.

How Thinking is Stimulated: Illustrated by the Evolution of the Cell

The following example, (taken from the revised Blue Version but which will be largely incorporated in the final Yellow Version) illustrates the hypothetical nature of science, and how teachers and students are put at ease in studying something for which the answer can never be completely known, namely, the study of how living cells evolved. This rationale follows after a brief consideration of Darwinian evolution, and the classical experiments of Redi, Spallanzani, and Pasteur which demonstrated that life does not arise spontaneously under present conditions.

The background developed is sufficient to immediately plunge the students into a speculative consideration of how life did get started. No one really knows the answer to this problem, and in fact no one ever will. But the hypotheses one develops regarding the probable origin of life have much to do with one's thinking about life and living things. By presenting the heterotroph hypothesis at this time, the writers have freed the teachers from a feeling of guilt when they cannot state the answer for certain By this organization the writers have, almost at the beginning of their study of biology, placed the student in the role of the scientist in trying to find the answer to some problem for which there is no known answer. Students must carefully consider what it means to be alive, and then speculate and experiment in trying to account for what must have happened at the time life developed And, currently, many leading biologists are relating much of their research to this problem of the origin of life Here is a contact with outstanding scientists as they push back the boundaries of what is known about the origin of life.

For an understanding of the probable origin of a living cell, a certain amount of both inorganic and organic chemistry are essential. The writers have succeeded in presenting this minimum amount clearly and in sufficient detail to permit the student to think through the many problems required for life to develop What has been written is organized around assumptions which must be fulfilled if primitive life is to develop from a non-living substance. Perhaps the best way to convey how the authors have done this is to outline the assumptions they have made in developing the section on the Evolution of the Cell:

*The Emergence of Life**

Assumption 1—The primitive earth contained an atmosphere composed primarily of simple gases—methane, ammonia, hydrogen, and water vapour. There was very little free oxygen, nitrogen or carbon dioxide.

a. Conditions on earth
b. Amino Acids

Assumption 2—Complex organic molecules were formed in the atmosphere from the available water, methane, ammonia, and hydrogen. These organic molecules were carried into the primitive oceans by the rain.

a. Stanley Miller experiment
b. Amino Acids
c. Proteins

Assumption 3—During millions of years an accumulation of organic molecules occurred in the earth's primitive seas. As chemical evolutions continued, more and more complicated molecules were formed by the chemical union of smaller molecules. The first organism evolved from a complex of organic molecules

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*Certain modifiations have been made in the final list since published. —Ed.

a Heterotroph hypothesis
b Ions
c. Coacervates

The Primitive Organism. Problems of Energy Utilization

Problems of any primitive heterotroph

(1) Obtain energy from the environment
(2) Reproduce
(3) Adjust to changing environmental conditions

Assumption 4—The primitive heterotroph survived by obtaining its energy for life from the organic compounds which surrounded it in the primitive seas

a Energy and Life
b Transfer and Storage of Energy
c. Transfer of Materials in the Cell
d. The Cell Membrane
e The Structure of Fats
f The Effect of Fat Solubility on Entry Into Cells
g The Effect of Molecular Size on Entry into Cells
h The Effect of Charge upon Entry into Cells
i. Cell Membrane and the Heterotroph
j. Motion of Particles
k. Diffusion
l. Active Transport
m. Active Transport in Human Muscle Cells
n. Active Transport and ATP
o Osmosis
p Natural Selection and the Heterotroph
q Fermentation
r. Carbohydrates
s. Energy Released in Fermentation
t History of Fermentation
u. Enzymes
v. Enzymes and the Heterotroph
w. Requirements for Enzyme Activity
x. Glycolysis (Fermentation in Muscle Cells)
y. Anaerobic Metabolism (Fermentation and Glycolysis)

The Primitive Organism. Problems of Duplication and Variation

Assumption 5—Along with the capacity to derive energy from organic compounds, some mechanism evolved which enabled the organism to duplicate itself accurately.

a. The Parts of a Nucleic acid Molecule
b The Watson-Crick Model of DNA
c. The Role of DNA in the Cell

Assumption 6—The Nucleic acids, which were self duplicating, in time were able to establish firm control over the basic cell processes.

a Transduction in pneumococcus bacteria
b Hereditary materials are found in the molecules of nucleic acids

Assumption 7—The DNA of the early cell contained the primary instructions to the cell about how it was to carry on its life activities. At the time of cell divisions the DNA instructions were transmitted to the newly formed cells.

a Three important questions about DNA:
  (1) How did the nucleic acids establish their control over a great variety of cellular processes?
  (2) How are the hereditary instructions to the all 'coded' in the DNA molecules so that the cell receives and correctly interprets the instructions?
  (3) How does the DNA molecule duplicate itself exactly, generation after generation, so that the code is faithfully transmitted to the descendents of the cell?
b The Self,duplication of DNA
c. The Hereditary Code
d. Meet the Viruses
e Sudden Changes in DNA

Assumption 8—Although the nucleic acids were usually replicated accurately, occasionally chemical accidents resulted in mutations which in turn modified the cell processes controlled by the nucleic acids.

a Families of DNA Molecules
b. DNA in New Combinations
c. Advantages of Sexual Reproduction

The Primitive Organism. Food Makers and Respiration

Assumption 9—The original organic materials in the oceans, lakes, and pools of the primitive earth were gradually consumed.

Assumption 10—Organisms which were able to utilize the radiant energy of sunlight to synthesize organic compounds gradually evolved.

This ability to utilize light probably evolved over a long period of time and was the result of the slow accumulation of small advantageous changes.

a. Bacterial Photosynthesis
b Carbon Dioxide Incorporation
c. Algal Photosynthesis
d. Respiration (Aerobic respiration)

Assumption 11—Over great periods of time, free oxygen accumulated as a by-product of photosynthesis and became available in high concentrations. During this time, living organisms developed chemical patterns of food breakdown which utilized this oxygen supply.

a. Oxygen as a hydrogen acceptor
b Aerobic and anaerobic metabolism compared
c. The mitochondria and the enzymes
d Krebs citric acid cycle
e. Energy transfer and storage

The Modern Cell The Evolved Heterotroph

a. The cell as a living unit
b. Cellular reproduction
c. Variation among unicellular organisms

By taking the student through the rationale related to the above assumptions, and by presenting to him the experimental evidence for believing the above assumptions, a stage is set for a consideration of the basic problems, faced by any living organism The student has had his attention focussed upon the basic problems of being alive, before he has become confused by the multiplicity of accessory organs found in many living organisms He is given an orientation which makes more meaningful his entire study of biology, and he is started in the study of biology by considering the problems of living things, and then inquiring into the methods by which these problems must have been met.

5

THE CHEM-STUDY PROGRAMME IN CHEMISTRY*

Introduction

There are many ways to teach chemistry. Past courses have been enormously varied, present courses explore many methods, and future courses are being planned with considerable care in many localities. Yet widespread discount exists among secondary school chemistry teachers, even those who are giving the most thought to planning improvements in their courses.

Examples of each of these sources of discontent are easy to come by. It is common to suggest that diffusion accounts for the rapid spread of odours throughout a room, and the explanation may be offered even after a conclusive demonstration with ammonia gas and hydrogen chloride that diffusion actually occurs at the rate of a meter an hour. Small wonder that the student is confused Most historical developments of the atomic theory end with a description of a modified Bohr atom, which was first presented in 1913 and replaced some ten years later. Hardly a recent idea Teachers are more likely to stress memorization of valence tables than an understanding of how these data originate or how they are tied in with the detailed structure of the atoms Long hours are spent balancing chemical equations with no discussion of the mechanisms by which the reaction occurs or the nature of the processes by which one set of chemicals can be converted into another. Laboratory notebooks typically contain blank spaces to be filled in by the student Generally, 50 to 90 per cent of the entries require only perusal of the textual material with no reference to laboratory work. In the laboratory the student is encouraged to get the 'right answer' rather than to investigate a system with some freedom of experimental design. Under such circumstances discontent and frustration are difficult to avoid

Clearly such deficiencies, whether or not they are overtly apparent to the instructor and the student, are intuitively felt by both, to the detriment of a satisfactory course. No single course can ever remove all the deficiencies, or attack with equal success any large number of them. Consequently there is a widespread feeling that a national effort needs to be made to deal with as many of these problems as possible .

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* Excerpts from Camnbell, J. Arthur, Chemistry—An Experimental Science, *The School Review* Vol 70, No. 1, 1962 & *CHEM-Study Newsletter*, Vol. 3, No. 2, 1963.

The Chemical Education Material Study, more commonly known as the CHEM-Study, grew out of suggestions by a committee headed by A. B. Garrett, of Ohio State University. In 1960, Nobel laureate, Glenn T. Seaborg, now chairman of the Atomic Energy Commission but at that time Chancellor of the University of California at Berkeley, obtained a grant from the National Science Foundation and assembled a staff to investigate what could be done to produce the most effective high-school chemistry course possible.

The general history of the study and an outline of its major areas of operation have been presented in some detail in the newsletters published by the CHEM-Study in Claremont, California In the summer of 1960 a group of well-known chemists assembled at Harvey Mudd College in Claremont As a result of their labours, a textbook and a laboratory manual were prepared and tried in twenty-four high schools during the 1960-61 academic year Some thirteen hundred students were involved in the tryouts Close contact was maintained between the staff of the study and the teachers The results of this trial were then given to a second writing group in the summer of 1961 at the University of California in Berkeley This group produced a second trial edition of the textbook and the laboratory manual and a complete teachers guide In both sessions the writing groups were composed of distinguished high school, university, and industrial chemists.

During the 1961-62 school year the test programme expanded to include one hundred and thirty high schools scattered across the United States Some thirteen thousand students in these schools studied CHEM-Study materials This sample provided much more definite evidence on the limitations and the strengths of the course Additional experimental schools were brought into the study during the 1962-63 academic year.

The importance of laboratory work is emphasized in many ways One is that the student normally does the experiment before he reads about the material in the textbook or before the material is discussed in class. The student is allowed to discover many of the fundamental ideas and relations himself and to discuss them in a laboratory context with his classmates, rather than to read about them or merely hear them described as things that can be observed

The student is sent to the laboratory the first day of school, and he works there about seven of the first ten days of school. He is not given his textbook until the fourth day of school This approach so intrigues the student that he comes to look forward to laboratory days He realizes that chemistry is indeed an experimental science, not a subject that can only be read about in a book or talked about in class.

As the course is now constituted, the first set of experiments involves a fairly extensive set of observations that centre on a candle. The student begins by writing down as many observations as he can make in a short period of time He then compares his list, which normally contains ten or twelve observations, with the list of a professional chemist, which contains fifty-three observations The disparity in the number and the quality of the observations comes as a shock and an eye opener to most students The student then studies melting-point behaviour, investigates the chemical changes that occur when a candle burns, identifies the products of the reaction. He also analyses the intermediate steps that must occur during the reaction. He measures the heat of combustion of candle wax and the heat of fusion of the wax, compares the two and relates the magnitude of these two energy terms to the operation of a candle. In the process the student is encouraged to generalize on the relative magnitude of the energy changes associated with chemical reactions and those associated with phase changes

About three-quarters of the laboratory experiments are quantitative in nature, but the level of mathematical ability required to handle the results is not too demanding for students at this level. A good comprehension of seventh and eighth grade arithmetic will enable the student to perform practically all the operations. Occasionally algebra is required, and it is certainly true that only a student with some comprehension of algebra could do outstanding work in the course.

Many experiments involve unknowns, and a considerable number of the experiments give the student options in methods of performing the experiment or in continuing beyond the dicoveries that the majority in the class will make. The intent is to encourage students at all levels to carry on a serious investigation and to discover effects that they were not familiar with. The equipment is kept simple in design and low in cost. Any school with a reasonable laboratory budget should have no difficulty in introducing these experiments into its programme.

A description of the first experiment in the overview section might be profitable The student weighs a piece of copper wire and places it in a solution of silver nitrate. Beautiful crystals of metallic silver begin to form, and the solution slowly turns blue. The aesthetic appeal of this experiment to the students should not be underrated The reaction is watched for a while and then put away so that it can come to equilibrium The residual copper is weighed, as is the silver that has been formed. From the weights of the copper used and the silver formed, the student calculates the ratio of moles of copper to moles of silver in the chemical reaction He is then asked to write a simple chemical equation in terms of moles of reactants and moles of products, applying the conservation laws concerning numbers of atoms, elements, and mass Next comes the question, 'if atoms of one of the two elements form ions of unit positive charge, what charge will the ions of the other element carry?' This is the first contact the students have had with ions, yet they seem to have little difficulty in realizing that the silver ion will have a single charge and that the copper ion must then have a double charge.

In the next experiment the silver is dissolved in nitric acid, precipitated with hydrochloric acid, and the resulting silver chloride is weighed. Analysis of these data enables the student to calculate the formula of silver chloride. He is then asked to use the data from the two experiments to predict the empirical formula of the chloride of copper. Remember, he has no prior knowledge of what a reasonable formula for this chloride might be This type of quantitative experimentation seems to intrigue the students, without proving overwhelming to the less capable ones.

The Textbook

The introductory section of the text book outlines the importance of an experimental approach and the tentative nature of the conclusions that will be reached. The importance of expanding the conclusions and of building a more inclusive model is developed from the beginning so that the student realizes that scientific observations are uncertain and that the resulting theories contain uncertainties Here as well as in the overview section the atomic theory is presented as something that the student has learned about from past education in science and as a theory he can use in understanding chemical observations.

This first section of the textbook introduces most of the fundamental ideas with which a chemist deals It gives a brief introduction to the electrical nature of matter, mole concept, kinetic theory, the idea of dynamic equilibrium, structural properties, energies associated with phase changes, the periodic table, and systematic variation of chemical properties with atomic number. In each case a minimum experimental basis is laid, but the full experimental treatment is deferred until later sections of the book. The purpose of this section is to acquaint the students with the general principles within which chemists operate

It seems to us that just as a painter first sketches on blank canvas the general areas that he will use in treating his subject, so a teacher should sketch out for his student the general areas he will be studying and give him a framework into which further details can be fitted The framework can be nebulous, but it should be adequate and, even at this level, it should be tied in with as much experimental evidence as is essential for the framework to hold together.

This section of the course has given us the greatest difficulty so far It is difficult for an experienced and competent teacher to defer detailed treatment of some of these ideas until the over-all framework has been constructed However, it has also been the experience of teachers who have completed the course that the approach has merit. One result of the approach is that the conceptual treatment and the bonding treatment seem to flow smoothly for the student He has a comprehension of how they fit together even before each one is developed in detail He has also developed a desire to understand general concepts in more detail, since he has seen that they do indeed fit together and give a coherent over-all picture

The second section investigates chemical reactions in terms of the concepts found useful in interpreting reactions. This subject is discussed in greater depth than is now common.

The third section deals with chemical bonding and structural relationships. The final section deals with systematic chemistry, involving a study in some detail of certain elements and compounds. In this last section considerable emphasis is placed on interpreting chemical behaviour in terms of conceptual ideas developed earlier in the course.

The more intensive treatments in the third and fourth sections are strongly dependent on the laboratory work that the student is performing. In addition, reference is often made to experiments that the student may not have had the time or the opportunity to perform in his own laboratory work A strong emphasis is placed on the dynamic nature of chemical systems, on the energy changes involved in reactions, and on the mechanism of approach to, as well as the nature of chemical equilibrium Particular attention is given to acid-base and oxidation-reduction systems as examples.

The discussion of chemical bonding is based heavily on the electrical forces that operate. A chemical bond is treated as existing because of the simultaneous attraction of a given electron or set of electrons by more than one nucleus. The development of ideas concerning atomic structure is traced up to the contemporary quantum-mechanical atom. It is pointed out that the position and trajectory of electrons are unknown but that it is possible to describe a general distribution of charge in space in terms of orbitals and their energy. These are related to experimentally determined energy levels. The formulas, structures, and shapes of chemical molecules are then correlated with the distribution of these orbitals in space and with the differences in energy of the available energy levels. It is hoped that the student will find in this section ample justification for the study of chemistry and a feeling of success in using the powerful ideas he has discovered earlier in the course.

The teachers guide parallels the laboratory manual and the textbook. For each chapter in the textbook there is a section pointing out the intent and approach, the outline, new concepts, schedule of related material, development, supplementary material (including a full discussion of each laboratory experiment), background discussion, and answers to exercises and problems for that chapter. The intent is to provide the teacher with the knowledge that he will find useful in interpreting the course and to ease mechanical duties, such as setting up laboratory experiments, working out answers to problems, grading papers, and making daily assignments. Preliminary comments from the participating teachers indicate that the guide is filling a long felt need and is most useful.

Chapter Titles and Experiments

Chapters	Experiments
1. Chemistry: An Experimental Science	1. Scientific Observation and Description
	2. Behaviour of Solids on Warming
	3. The Melting Temperature of a Pure Substance
	4. Combustion of a Candle: A Class Experiment
	4a. Further Investigations of a Burning Candle

	5. Heat Effects
2. A Scientific Model· The Atomic Theory	6 The Weights of Equal Volumes of Gases 7. The Behaviour of Solid Copper Immersed in a Water Solution of the Compound Silver Nitrate
3 Chemical Reactions	8. Mass Relationships Accompanying Chemical Changes I 8a. Mass Relationships Accompanying Chemical Changes II 8b The Formula of a Hydrate
4. The Gas Phase: Kinetic Theory	9. A Quantitative Investigation of the Reaction of a Metal with Hydrochloric Acid
5. Liquids and Solids: Condensed Phases of Matter	10 An Investigation of the Reacting Volumes of Two Solutions of Known Concentration 11. Reactions Between Ions in Solution
6. Structure of the Atom and the Periodic Table	
7. Energy Effects in Chemical Reactions	12. A Study of Reactions 13. The Heat of Reactions
8. The Rates of Chemical Reactions	14. A Study of Reaction Rates I 14a. A Study of Reaction Rates II
9. Equilibrium in Chemical Reactions	15 Chemical Equilibrium
10 Solubility Equilibria	16 Determination of the Solubility Product of Silver Acetate
11. Aqueous Acids and Bases	17 The Heat of Some Acid-Base Reactions 18. The Determination of the Hydrogen Ion Concentration of Solutions Using Indicators 19. Applying LeChatelier's Principle to Some Reversible Reactions
12. Oxidation-Reduction Reactions	20. An Introduction to Oxidation Reduction 21. Electrochemical Cells
13. Chemical Calculations	22 Ionic Reactions 23. A Quantitative Titration

14. Why We Believe in Atoms	24. Construction of a Logical Model
	25. The Relation Between Moles of Copper, Moles of Silver and Moles of Electrons Involved during Electrolysis
15. Electrons and the Periodic Table	
16 Molecules in the Gas Phase	26 The Investigation of Some of the Properties of a Pair of Cis-Trans Isomers
17. The Bonding of Solids and Liquids	27 The Packing of Atoms or Ions in Crystals
18 The Chemistry of Carbon Compounds	28 Some Reactions of Hydrocarbons and of Alcohols
	29 Some Derivatives of Organic Acids
	29a. The Preparation of Some Polymers
19. The Halogens	30. The Electrolysis of Aqueous Potassium Iodide
	31. Some Chemistry of Iodine
20. The Third Row of the Periodic Table	32 Some Chemistry of the Elements of Row 3
	33. Development of a Scheme of Qualitative Analysis Using Reagents Labelled A, B and C
21 The Second Column of the Periodic Table: The Alkaline Earths	34. The Relative Solubilities of Some Compounds of the Metals of Column Two—Qualitative Analysis
	35 Qualitative Analysis of Ag^+, Hg^+, Pb^{+2}
	36. Development of a Scheme for the Analysis of an Unknown Containing Various Anions
22. The First Row Transition Elements	37 The Separation of Some Transition Metal Ions with an Ion-Exchange Resin
	38. Some Investigations into the Corrosion of Iron

23 Some Sixth and Seventh Row Elements
24. Some Aspects of Biochemistry: An Application of Chemistry
25 Geochemistry: The Earth as a Source of Material

39. Preparation of a Complex Salt and a Double Salt
40 Preparation of Potassium Dichromate
41 Preparation of Chrome Alum

The laboratory manual includes the following appendices:

A-1 A Description of a Burning Candle
A-2 Laboratory Techniques
A-3 Measurement—The Metric System
A-4 Experimental Errors
A-5 Some Mathematics Useful in Chemistry—Exponents, Graphing Relationship, Combing Equations
A-6 Optional Experiments 4a, 8a, 8b, 14a and 29a
A-7 Names, Formulas and Charges of Some Common Ions
A-8 Oxidation-Reduction Half-Reactions in Aqueous Solutions
A-9 Relative Strengths of Acids and Bases in Aqueous Solutions
A-10 Solubility of Some Common Inorganic Compounds in Water

6

THE GENERAL SCIENCE SYLLABUS DEVELOP FOR INDIA

Since universal education in India extends through the primary schools, it is paramount that there should be included in the primary schools those ideas and approaches of science essential for the future citizens to live well ordered lives in a rapidly developing technological society The elementary school should extend the pupil's orientation in the sciences enabling him to make wise decisions as a participant in a democratic society, and laying for him a proper foundation for the study of science in the secondary school

Such a foundation is essential not only for the science students but also for those who will pursue the humanities and perhaps become teachers in the primary schools For the science students, the future scientists of India, a sound foundation in science in the primary and middle schools enables them to make rapid progress if they are to become successful scientists.

The lives of each of us are touched everyday by the forces of change Much of this change is due to the impact of science As the nature of the world is becoming increasingly determined by technology, it is certain that every individual needs some understanding of science to comprehend the world and live in it intelligently. India's progress depends upon how successfully her citizenry comprehend the basic principles of science and appreciate what science has to offer in the improvement of health and living conditions and in the promotion of agriculture and industry

How to Achieve the Objectives of Teaching General Science

A child should learn from his earliest years about things that are close to him around the home and the school Gradually, with increasing age, his horizon widens to include the community, the state, the country, and finally the whole world. Throughout his early impressionable years a child's study of science should give him an understanding of how to make life richer, safer, happier and more productive, both for himself and for society.

To the young child, the world is all in one piece. His science should be broad and encompassing, not broken into tiny fragments or specialized disciplines, such as chemistry, physics or biology. If the child is to grasp the true meaning of science and continue to use its methods throughout life, he must be involved personally in seeing and solving the problems of his own life This can only result from a direct acquaintance with science from the earliest school years.

How the Syllabus has been Developed

The first effort to make a syllabus for classes I to VIII was made by the National Council of Educational Research and Training at the request of the Punjab Government. Workshops were held in New Delhi where science teachers from various states got together, examined existing syllabi and developed a syllabus selecting major topics and concepts to be included in the general science course for classes I to VIII The advice of several specialists was obtained on this syllabus. A series of general science texts based on this syllabus were written by a number of authors This series included teacher's guides and work books for classes I and II, and textbooks for classes III to VIII. These texts have been translated into both Hindi and Punjabi and are currently in use throughout the Punjab State.

It was now felt necessary to re-examine this syllabus with a view to developing an all-India general science syllabus for classes I to VIII Two workshops were arranged for this purpose, one in Delhi in September 1962; and the other in Bangalore in November 1962. Representatives were invited from various states At this workshop the first draft of an all-India *General Science Syllabus** was prepared. It was decided that any topic introduced should be studied in sufficient depth so that the sub-concepts and concepts would be understood by the pupils and not merely memorized by them. The broad areas of content included in the syllabus are

1 Air, Water and Weather. Classes I to VIII
2 Rocks, Soils and Minerals. Classes I to VII
3. Human Body, Health and Hygiene. Classes I to VIII
4. Safety and First Aid. Classes I to VIII
5. Housing and Clothing. Classes I to VII
6. Energy and Work. Classes IV to VIII
7. Matter and Materials. Classes V to VIII
8. Living Things. Classes I to VIII
9. Plant Life. Classes I to VIII

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* Copies available from the Chief Publication Officer, N.C.E.R.T., 114 Sunder Nagar, New Delhi-11.

10. Animal Life. Classes I to VIII
11. Scientists at Work Classes I to VIII
12. Measurements Classes III and IV
13. Our Universe Classes I to VIII

All the major and sub-concepts for each of the areas were written as declarative statements so that these would serve as directives as to what to teach, specially for those teachers relatively uninformed in science A beginning was made in writing activities to be used in developing each sub-concept. The main outlines for the syllabus were written in Bangalore and much of the editing was done later at New Delhi by officers of the N C.E R.T The concepts and sub-concepts have been checked for accuracy and appropriateness.

Two supplementary books of activities are planned to follow this syllabus, one for classes I to V and another for classes VI to VIII. These books will contain background material for the teacher, and describe experiences, and in many cases, experiments to use in developing an understanding of each of the sub-concepts presented in the syllabus.

It is hoped that a series of general science texts for classes I to VIII will be written for teaching the concepts of this syllabus. Plans are tentatively made to write such a series in English and to make them available to the states

One of the commanding reasons for the efforts that have been put into the writing of this syllabus and accompanying books, and that are projected in the writing of the texts, is that the teachers in the primary and middle schools have an exceedingly poor preparation to teach science Consequently, it is necessary to prepare the materials that will at once suggest to the teachers what to teach, and give them materials to use in teaching. These materials should teach the teachers as well as the pupils Such a programme seems essential as India makes its giant strides towards universal education up to the middle schools and then up to the secondary schools.

7

INAUGURAL ADDRESS AT THE PHYSICS SUMMER INSTITUTE

D S. KOTHARI*

The blessing of the nineteenth century has been the extremely rapid growth of scientific knowledge It is universally acknowledged that we cannot have good university education unless we have good schools For the nations progress, it is essential to have good schools and vigorous universities. Unless we make an earnest attempt to make progress rapidly by bringing together the universities and the schools, the wide gap existing between them will widen further There is, therefore, an urgent need to bridge the gap which is existing between our schools and the universities

I am very happy that this summer school for high school physics teachers is being arranged jointly by the National Council of Educational Research and Training, the University Grants Commission and the U.S Agency for International Development. I am confident that we shall have many more such summer schools and that this process will go on like a chain reaction, that we shall have a large number of summer schools in the years to come so that hundreds of teachers will be enabled to gain this wonderful educational experience

By far the greatest contribution to this summer school in physics has been the book and the laboratory materials which have been kindly supplied to the seminar by the U S. Agency for International Development. I think very highly of all these materials I regard them as a very good proof of cooperative effort in their development A lot of thinking has gone into the production of these materials The new programme of physics teaching has been successfully implemented in the schools of the United States Far more important than the content in the book is the approach which is extremely teaching.

At present, there is almost a revolution in the teaching of science. It is taking place in all countries. There is a lot of ferment going on in many countries regarding the teaching of science at the secondary school level. For example, the Science Masters' Association in the U.K have also produced a book for the improvement of science teaching.

Growth of scientific knowledge in recent times has been truly remarkable, and what is even more remarkable and significant is the extremely rapid increase in the rate of growth Scientific knowledge and activities directly related to science are getting doubled in a short period of 15 years This doubling period can be estimated in different ways from the increase in the number of scientists, the increase in the number of scientific papers reported, the increase in the number of scientific magazines and in many other ways No matter what index is used, the doubling period turns out to be about the same This doubling period over the last 100 years has on the average, been some 10 to 15 years

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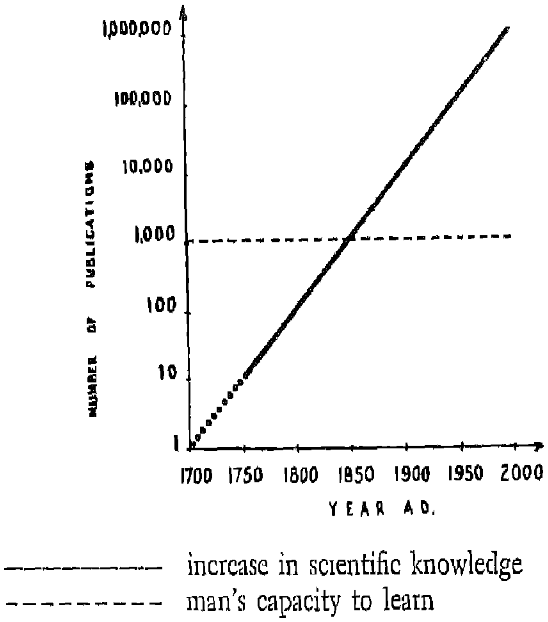
*Dr. D. S, Kothari is Chairman of the University Grants Commission, New Delhi

Man's capacity has not kept pace with this growth in the quantity and complexity of knowledge Man's capacity to learn has not changed appreciably since prehistoric times There was a time when a single person could encompass all of the sciences It is now almost too difficult for a person to know all of the branches of physics, although there were a few such persons in the late 19th century The days of the encyclopedists who dealt with all branches of science were over somewhere about 1860 Thus the day has come now when there are but a few outstanding persons who know all branches of their subject; more and more people today know only one of the sub-divisions of their own subject. While at present there are a few people who know about all of the branches of their subject, the day is not far off when there will be people who will not know anything beyond their field of specialization

With scientific knowledge doubling about every 15 years, it then increases about 100 times in a century Yet man's capacity to learn does not change, and at about the middle of the 17th century it was about all one could do to encompass a single subject such as physics Modern science began about 1700 This situation can be graphically portrayed as is shown

At the present moment, scientific subjects can be classified under 140 classes It is hardly possible for a person to be even a master in his specially Now-a-days, one can hardly be a total physicist Therefore, if one has to learn all of the important aspects of physics, it cannot be done through too much specialization, but must be accomplished by deletion of unnecessary knowledge Physics is a close unity. We must learn more about the principles which have universality rather than burden ourselves with the other details, which can be deleted. We must concentrate more on such principles even at a university stage as well as at a high school stage. One such important principle is the relationship between space and time rela-



tivity. Another is quantum theory. We must lay stress on these important principles

It is, therefore, necessary to devise ways and means for deletion of unwanted details and to concentrate on the more essential needs. The P.S.S.C. Physics book is a magnificent effort in this direction Little non-essential material is included and stress is laid on quantum theory and relativity throughout the book. I think that there should have been more stress on mathematics in this book. It might be possible later to introduce more mathematics into the book This book is indeed rich in subject matter. By far the most important feature of this book is the simple experiments which can demonstrate the validity of important theories. Many simple experiments can demonstrate important physical principles. For example, a simple moving hand can demonstrate the working of a pendulum. It should be interesting to think of forces at work when a tonga moves—what forces are applied and in what manner

A teacher cannot be an inspiring teacher unless he himself knows what is to be taught and also how to express his thoughts. It would be difficult for our school teachers to present the ideas even in the book because of their inadequate knowledge of English. It is, therefore, necessary for the teachers also to know the language well. In this connection, I would like to invite your attention to the recent article by Professor Taylor in the November 1962 issue of the Bulletin of the Physical Society, where he points out that, 'The teacher cannot be effective as a teacher of science, and tolerate slovenly English The pupil cannot construct anything of scientific value if he be unable to use the tool of language The duty of a scientist to teach good English is as insistent as his compulsion to teach exact science' Our teachers should also make efforts to master the language as far as possible.

It is universally recognized that good and progressive universities can only exist if we have strong and good schools To bring this about, it is necessary that there is no unduly big gap between the universities and the schools, and everything possible should be done to bring together and to establish channels of communication between university and school teachers A Summer Institute such as is this, therefore, to be welcomed from every point of view There is no doubt that it will make a valuable contribution towards the progress of physics teaching in the country

PART TWO

SUMMER INSTITUTES AND SEMINARS

PART TWO

SUMMER INSTITUTES AND SEMINARS

8

SUMMER INSTITUTE PROGRAMMES FOR SECONDARY SCHOOL SCIENCE TEACHERS

N. E. BINGHAM

This summer for the first time in India there were held four Institutes for science teachers, one for Biology teachers in the University of Madras, one for Chemistry teachers in the University of Poona, one for Physics teachers in the University of Delhi, and one for Mathematics teachers in Ramjas College, Delhi. These Institutes were jointly financed by the National Council of Educational Research and Training, the University Grants Commission, and the United States Agency for International Development

Participants for each Institute came from all over India. There were approximately 40 participants in each Institute Most of the participants had both a B Sc. and an M Sc degree, and these 160 participants were selected from approximately 800 applicants.

The Biology Institute was directed by Dr. S. Krishnaswamy, Professor of Zoology, University of Madras. His staff included Dr. Glen Peterson, Professor of Zoology, University of Houston, in addition to local staff. Dr. Peterson had participated in the development of the Biology text materials in America, which materials were used in this Institute.

The Chemistry Institute was directed by Dr. H. J Arnikar, Head of the Chemistry Department, University of Poona. He was assisted by Dr Donald A. Starr, Professor of Chemistry at Malone College, Canton, Ohio, and for a short time by Dr. J Arthur Campbell, Chairman of the Chemistry Department, Harvey Mudd College, Claremont, California, in addition to local staff. Dr. Campbell is director of the CHEM-Study Committee which developed the text, laboratory manuals, teachers guides and films used in this course.

The Physics Institute was directed by Dr R. C. Majumdar, Chairman of the Physics Department of Delhi University. He was assisted by Dr. Kenneth Baker, Professor of Physics, Union College, Schenectady, N. Y as well as by local staff The Physics Institute used the materials developed over the past eight years in the United States by the Physical Science Study Committee, known as the PSSC Programme. The text itself has been reprinted in India and is available at the Publication Unit, N.C.E.R.T., 114, Sunder

Nagar, New Delhi, for the amount of Rs 8 plus postage. Besides the text, the participants of the Institute used the Teachers Manuals, Laboratory Guides, supplementary books, kits of equipment, and the 54 films of experiments developed as a part of the PSSC Programme.

The Mathematics Institute was directed by Dr. P. D. Gupta, Principal of Ramjas College, Delhi. He was assisted by Dr. Emory Starke, Professor and Emeritus, Chairman of the Mathematics Department of Rutgers University, New Jersey, by Dr. Shanti Narayan, Principal of Hans Raj College, Delhi, and by other local faculty. This Institute used the extensive array of mathematics materials developed in the United States by the Secondary Mathematics Study Group known as the SMSG Programme, which introduces the students to higher mathematics in a modern way.

Each of these Institutes was of approximately eight weeks duration. Each was enthusiastically conducted by the faculty and enthusiastically participated in by the teachers. These Institutes were experimental in nature Emphasis was placed upon investigatory activities—activities in which the participants used the laboratory to experiment, to collect data, and to interpret the data so obtained. This is the way a scientist uses a laboratory. Since science is advancing so rapidly on all fronts, the emphasis in these new programmes is upon finding and understanding those ideas that have universality, ideas which can be used to interpret a wide number of related phenomena. It is hoped that the participants will find many ideas and procedures that they may use in updating and improving science instruction in India.

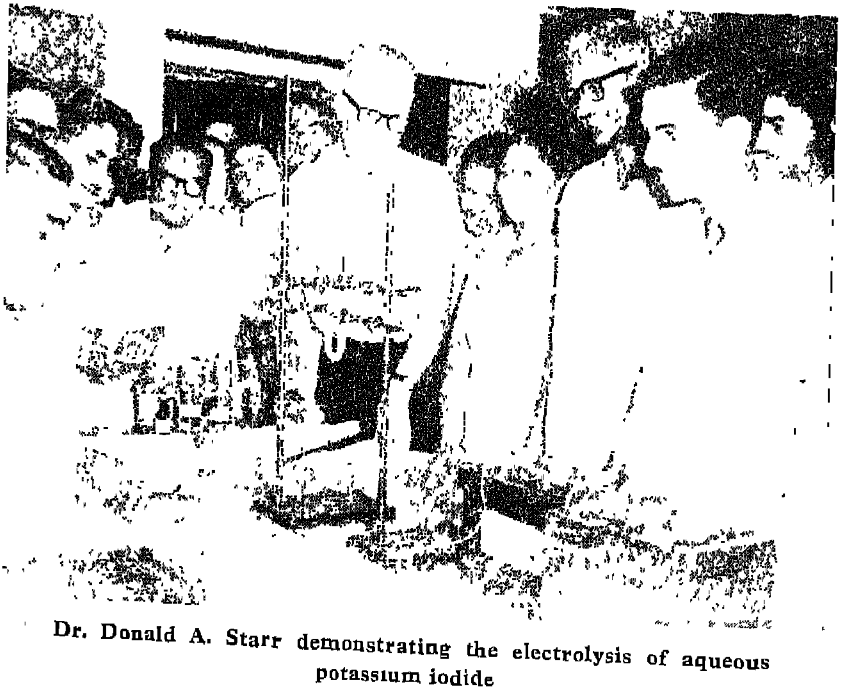
Laboratories were used extensively in each of the Institutes and these laboratories were chiefly investigatory laboratories rather than exercises in which students checked upon the answers they had already read in the text. The laboratory activities preceded the discussion of such activities and served as a basis for the development of concepts. Emphasis was placed upon thinking rather than upon memorization of conclusions.

The chief concern of the participants seemed to be how they can bring all these new ideas and approaches, which they find so stimulating, into the classroom How can they teach in their own high school programmes what they were taught in the Institutes? In these Institutes, ideas emerged which did show that many of the universal ideas of science may be taught in the classrooms of India. The teachers found ways by which they could devise and conduct experiments to facilitate the learning of students.

Dr. A L Mudaliar, Vice-Chancellor, Madras University, addressing the BSCS trainees at the valedictory function

Dr. N. E. Bingham with participants in their study of fermantation

Mrs. Anna Singh shows how to use the ripple tank



Dr. Donald A. Starr demonstrating the electrolysis of aqueous potassium iodide

Because of the success of these Institutes this year, plans are already being made by the University Grants Commission, the National Council of Educational Research and Training, and the U S. Agency for International Development to expand this programme this coming year. This programme of Summer Institutes for secondary school science teachers is one of the most fascinating experiments in education that has occured in India

9

SUMMER INSTITUTE IN BIOLOGY UNIVERSITY OF MADRAS

S. KRISHNASWAMY*

REPORT

The New Approach to Biology Teaching

Scientific discoveries are made so rapidly now-a-days, that it is virtually impossible to keep pace with their progress To bring these rapid advances to the school children, it becomes necessary to modify substantially the content as well as the methods of teaching In this new approach, the high school students learn the facts by performing the original experiments which led to the discovery of those facts. In other words, they live as scientists and discover the facts for themselves This helps in a better understanding of the problem and leads to an intuitive grasp of the subject instead of mechanically memorizing a few facts. Therefore, in this new approach students will spend more time in the laboratory than in the lecture rooms and discover the laws of nature themselves.

The specially prepared textbooks and laboratory guides lead the students by stages from the simple to the more complex problems in biology. These text materials are augmented by films, film strips and other teaching aids.

The writers of the new biology texts have placed emphasis on the unifying threads of life and the importance of laboratory work, through which a student becomes a participant in the exciting field of science and not a mere outsider who reads about science and watches demonstrations

The Summer Institute at Madras was designed to bring to the notice of the practising science teacher these new biology materials and give them direct experience in the use of these materials.

Participants

This Institute had forty participants drawn from almost every state in India Many of them had wide teaching experience The following data will give a fair idea of the range of educational and professional experience

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*Dr. S. Krishnaswamy is Professor of Zoology and Chairman of the Zoology Department, Madurai University, Madurai.

State-wise distribution of participants

Andhra Pradesh	2
Assam	2
Bengal	3
Bihar	2
Gujarat	2
Delhi	8
Kerala	5
Madras	3
Madhya Pradesh	4
Maharashtra	1
Mysore	1
Orissa	1
Punjab	2
Rajasthan	2
Uttar Pradesh	2
	40

The Programme

Lectures and Practical Work. The syllabus set out in the BSCS Yellow Version was followed during the course Over 75 lectures and practicals were held during the course

Special Lectures Besides the regular lectures covering the material in the syllabus, special lectures by experts were arranged on the following topics to supplement the material in the BSCS Yellow Version

Energy utilization by Prof. C. P. Gnanamuthu
Tissue culture by Dr. Manohar Lal
Parasites and diseases by Dr. L. N. John
Research in high schools by Prof. R. V Seshayya
Electron microscopy by Dr T. V. Desikachari
Virus by Prof. T. S. Sadasivan
Algae by Mr S. Doraiswami
Orientation in bats by Dr Neiweiler
Museum techniques by Mr. G. J. Phanuel

These lectures supplemented the text material in BSCS Yellow Version

Discussions: Work for each week was reviewed and discussed on Fridays and Saturdays The problems facing the teachers were vividly brought out in these discussions. Suggestions were given for improving the quality of the lectures The participants were able to present their points of view on various aspects of teaching biology.

A discussion on the Outlook of Biologists was led by Dr. B. S. Bhimachar, Director of Central Inland Fisheries.

A fascinating approach to teaching known as 'Invitations to Enquiry' was introduced. The participants were so pleased with this approach that one of them, Mr Verma, led a class on the subject showing that the methods could be followed in our schools without any difficulty.

New Methods of Evaluation: Dr. N. E. Bingham, Science Consultant, U S. AID, acquainted the participants with the new methods of evaluation developed in U.S.A. The participants discussed these methods. After discussion, they set up similar questions on selected topics.

Research Talks: Dr. Glen Peterson gave a research talk on Cholesterol Synthesis by Microorganisms. This gave an opportunity for the participants to learn the method of presenting scientific papers to an audience This was followed by research talks by two of the participants, Mr. Sutaria and Mr. Agarwal They presented the results of their original work.

Research Prospectus and Laboratory Blocks: The research prospectuses prepared by BSCS were discussed and several lines of investigations were suggested as group activities. The teachers evinced great interest in these projects.

The Laboratory Blocks were introduced at this stage. The teachers were given an opportunity to study the blocks to try and see if they could introduce them in their schools. Special stress was laid on improvising apparatus and several suggestions were given.

Evaluation of the Institute.

In the beginning, the participants were not convinced that the new methods of teaching could be applied to Indian schools. At the end of the seminar, a questionnaire was distributed to the participants to elicit their reactions to the programme. Only eight out of the forty felt that they could not implement the new programme and methods of teaching. Five said that they did not have adequate laboratory facilities to carry out the experiment. All of them said that some changes were necessary if they were to implement the new approach First, adequate time should be set apart for practical work Secondly, sufficient flexibility should be provided in the syllabus to try new materials and methods Thirdly, administrators, principals and heads of schools should be oriented to the new methods through short courses of about three days duration so that they might assist and encourage schools in adopting an experimental approach

Suggestions for the Future

1 Courses of shorter duration should be held for teachers from training colleges These should be of about two weeks duration

2. With the help of teachers trained in the Institute, 3-day discussion groups should be organized for educational administrators

3 As an experimental measure, the new syllabus may be introduced and tried in the higher secondary schools proposed to be started by the Centre in different parts of the country. This would have considerable influence on the schools in the region and may bring about the desired change.

B EVALUATION

Observations of Members of the Coordinating Committee

This Institute was somewhat shorter in duration than the other Institutes, as it was terminated on June 26 because, with the beginning of the new school year, hostel arrangements could not be made after that date However, it proved a first-rate Institute in every respect. The total length of the Institute was compensated for by starting the programme early in the morning and continuing till late in the afternoon, and by conducting these programmes on a six-day week basis. As in the other Institutes, provision was made for trips to places of special interest on Saturdays. The sea-side location made it interesting to the participants, particularly to those who came from inland locations.

The faculty of the Institute took particular pains to examine and try out all the new materials These materials included the Yellow Version BSCS Texts, Student Laboratory Manuals, and Teachers Guides, the Teachers Handbook for all Versions, and the two volumes of Biological Investigations for secondary school students which were given to each of the participants. The ten Biological Technique Films of the BSCS programme and the 50 films of the EBF Biology Programme were made available and used in the Institute. All these direct experiences with the entire programme gave the participants confidence that the new biology programme can be appropriate to their schools.

In the laboratory most of the experiments of the new programme were done by the participants All the materials for this laboratory were procured locally. In fact, Dr. Krishnaswamy calculated how much it would cost to equip the laboratory to teach this new programme. He found that all materials could be produced locally and that a laboratory could be equipped for about Rs 1,400 including all the specimens that would be used Most of this equipment could be used year after year So this represents an initial expense. This list of materials (available in India) to teach the new biology programme is given in Appendix C

A number of seminars were held where the students discussed with the faculty and with visiting guests the new approaches and content to teach biology, which of these might be included in the schools in India and how they might be included. Among other things it was decided to publish a fortnightly newsletter among the members in which the participants may tell how and to what extent they have been successful with the new ideas which they have learned this summer. Without exception the participants in the Biology Institute were enthusiastic about their summer experience

By Dr Glen Peterson, Visiting American Scientist

This Institute was conceived as an experimental Institute to try out the new Biological Sciences Curriculum Study (BSCS) Programme to find to what extent parts or all of this are appropriate for adoption by secondary schools of India This BSCS Biology programme differs from conventional biology in several ways Firstly all the BSCS materials have significant unifying threads Secondly, BSCS biology differs from conventional biology in that it is a general secondary school programme, that has resulted from a genuine co-operative approach between significant teams of research biologists, high school biology teachers, and other contributing specialists. Thirdly, the traditional illustrative type of laboratory exercise is de-emphasised as stress is given to investigative exercise which introduce the student to the inquiring processes of science.

It is the considered opinion of the writers of BSCS biology that the unifying threads of themes as the structure for the secondary school biology course more adequately reflect the modern biology than do conventional approaches The central position of the laboratory reflects the conviction that a student comes to understand science, by participating in science rather than serving as a bystander who only reads about science, watches demonstrations or routinely follows patent work outlines.

This Biology Institute in Madras was organized and conducted in a way that the participants not only tried out the materials but they also experienced the approach of the new BSCS programme It is their considered opinion and mine also that most of the BSCS programmes, both the approaches and the materials, are appropriate for use in the secondary school programmes of India. The adoption of these approaches and these materials would do much to remove obsolescence and upgrade the teaching of biology here

I wish to commend the Director and faculty of this Institute for the many things they have done to make this experience a first-rate experience for all the participants, and to make it possible for the participants to practise many of the things they have learned here, when they return to their various schools. For example, a special bibliography of reference books was prepared and recommended for use in Indian schools. A complete list of all the materials and equipment necessary to do all of the experiments of the programme, and also the Indian sources of such materials was provided for each of the students.

Several trips of particular interest to biology teachers were arranged Extra preparations were made for these trips, for example, a special bulletin was prepared on how to know water birds of Vedanthangal Opportunity was provided for those who live inland to collect seashore specimens to take home and use in their teaching

Certain of the lecturers were recorded and copies supplied to the participants so that they could have a complete set.

Attention was paid to the many details which are so essential for a sustained period of comfortable living when away from home. All in all, one may say that this Institute may well serve as a prototype for future institutes to be held in India.

By Participants

Fifty-eight per cent of the 40 participants in the Biology Institute responded to a questionnaire. Below are summarized their responses to four of the questions Each tally refers to the number of participants indicating a particular idea The responses are categorised by topics

I In view of the purposes of the summer seminar to upgrade secondary school science education, which experiences in your summer seminar, do you value most? Why?

The approach

- a) The Yellow Version BSCS of much use, as our libraries have few aids to teaching—8
- b) Approach to teaching biology from the functional and physiological aspects, a nice method—2
- c) Teaching biological sciences as a whole is ideal—not botany and zoology as single units—2
- d) 'Invitations to Enquiry' are simple and produce wonderful results—6
- e) Such an approach gives an enthusiasm for science to pupils—5
- f) Teaching biology at the molecular level will fill the gap between plants and animals—1
- g) The emphasis is on thinking rather than memorization—2
- h) The Yellow Version and the syllabus in India should be combined—1

Updating of Subject Matter

- a) Most lectures were valuable especially those on evolution and animal behaviour—2
- b) New information for me as a teacher—9
- c) Theory lectures of value to me—4
- d) I got much impetus to work further in my subject—1
- e) The seminar gave me a chance, I never would have had, to compare ideas with those of others in my own profession—1
- f) Subject matter most valued:
    - Study of microbes—5
    - Culture media for microorganism identification—7
    - Study of cell division—2
    - Animal behaviour—3
    - Chromatography—3
    - New theory in plant and animal physiology—4
- g) The seminar enriched me with the modern aspects of the subject, which ultimately I shall pass over to my students—1

Experimental Method (Laboratory and Field Trip)

- a) Practicals of most value—13
- b) Practicals helpful to create scientific thinking—3

c) Practicals illustrative and demonstrative—2
d) Practicals of much use to pupils, they have to come to conclusions—2
e) I found a new way of teaching which helps our students to think something about the subject—1
f) Pupils will be made to observe by themselves—2
g) I shall be able to show the simple experiments to bring my students in close touch with facts other than only the book knowledge—1
h) The experimental side will give a clear cut idea of the subject Such experiments as on animal respiration, culturing bacteria, etc will arouse the real interest for the subject amongst the students—1
i) Practicals are so important they should all be done by individuals, not by groups Only in this way can real learning take place—8
j) Great help to study biology in its natural setting—1
k) Let the pupils prepare slides and projects—1
l) The knowledge gained by seeing is lasting—1
m) Field trips get students enthusiastic—2
n) Everything could be learned by doing—1
o) Let the pupils read more than the textbook—1
p) This kind of method takes a lot of time and skill A teacher has to handle 250 students, cannot finish syllabus and conduct laboratory experiences—1

Films

a) The film-shows were one of the most valued parts of the seminar—8
b) Visual aids were very applicable, were illustrative and informative—7
c) Film shows such as these will create scientific thinking in students—2
d) Many films gave a clear idea of ecological regions—1
e) They made theory clear, so practicals can be demonstrated better—1
f) Such films should be available to schools—4
g) Modern techniques were well brought out—3
h) Things beyond the pupils' imagination and environment can be brought nearer to them—1

Discussions

a) Discussions gave me an idea of new approach—6
b) Cleared many doubts and so I am now better equipped—7
c) Informal discussions have much value—2
d) We learnt of others' difficulties and ways to overcome them—5
e) Discussions with eminent scientists inspired us to greater knowledge—1
f) I learnt about other methods being used in other parts of India—1

II Using the present syllabus, can you see ways to introduce new content and new approaches in your classes? To what extent can you do this? Give an example.

Extent of Use

a) Almost all the experiments can be used except those involving electrical apparatus—1
b) All who answered stated that there were a number of ways the new content could be introduced with such reservations as need of equipment for sterilization, need of microscopes, and more time—23
c) I can conduct investigatory experiments, because I had this experience—2
h) Yellow Version BSCS and the present syllabus should be continued—3
i) Conduct seminar in accordance with present syllabus (VIII-XI) and then teacher can apply—4
j) Give more time to applying ideas in the classroom—3

Administration of the Seminar

a) Training college teachers should participate—7
b) Seminar should be shortened and held in a place where flora and fauna are prevalent—3
c) Summer seminars should be confined to each state so that more teachers can participate—2
d) Mixing B Sc. degree holders with M.Sc. degree holders gives rise to difficulties for former—1
e) Attach present participants to new seminars for next summer —2

10

SUMMER INSTITUTE IN CHEMISTRY UNIVERSITY OF POONA

H J ARNIKAR*

The Chemistry Summer Institute was inaugurated by Dr. K Venkataraman, Director of the National Chemical Laboratory, Poona, on May 13, 1963. It was attended by 38 secondary school chemistry teachers coming from the different states of India as follows:

Andhra Pradesh	4
Bihar	2
Delhi	1
Gujarat	2
Kerala	3
Madhya Pradesh	5
Mysore	3
Orissa	2
Punjab	1
Rajasthan	4
Uttar Pradesh	2
West Bengal	2
Maharashtra	7
Total	38

Of these 38, twenty-one were B Sc s and seventeen were M.Sc.s. Twenty-seven had also a teaching degree in addition The teaching and research staff of the University Department of Chemistry conducted the classes of the Institute, following the Chemistry Study programme of the U S.A. The normal daily schedule of the seminar was as follows.

11-30 a m. — 12-30 p.m. Lecture
12-30 p.m. — 1-30 p.m. Discussion of practical work
or
Model classes on short topics by the participants
1-30 p.m. — 2-00 p m. Break
2-00 p m — 5-00 p m Laboratory Work

Every week an achievement test and two or three CHEM-Study films were arranged. Visits to chemical industries, and research centres in and around Poona were arranged during week-ends. The whole-time presence of a Senior Professor of Chemistry, experienced in the adoption of the CHEM-Study courses, as Dr. Donald D Starr, Head of the Science and Mathematics Division of the Malone College, Ohio, (U S A) was of invaluable help in the successful adoption of the novel CHEM-Study courses in all their aspects. The periodic visits of Dr N Eldred Bingham, Science Education Consultant, U.S A I.D. helped in assessing the progress of the Institute from time to time The programme was further enriched by the participation of Professor G V Asolkar, Head of the Chemistry Department, University of Nagpur, and of Professor B D Jain, Chemistry Department, University of Delhi Dr. Jain devoted much time to the problem of revising the existing syllabus in chemistry and the adoption of a new experimental approach. Mr James Greene of the Asia Foundation visited the Institute and had discussions with the participants and the faculty members, to assess the success of the CHEM-Study materials in teaching chemistry in this country

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*Dr. H. J. Arnikar is Professor of Chemistry and Chairman of the Department, University of Poona, Poona.

The highlight of the Institute was the visit of Professor J. A. Campbell of the University of California, Berkeley and collaborator of Professor G T Seaborg, the Director of the Chemical Education Materials Study (CHEM-Study) Professor Campbell spent four days with the Institute and conducted model classes, beginning with an experimental demonstration and ending with a discussion of the observations. These were unique illustrations of the CHEM-Study method of performing the experiment, noting the observations, then attempting to explain them, and finally testing out the validity of each explanation

Other visitors to the Institute were Dr Bowling of De Nobili College, Poona, for about two weeks and Dr. Campbell of Spicer College, Poona Some secondary school students of Poona were also invited to attend a part of the course and one of them stayed till the end and showed keen interest at every stage.

The CHEMS materials include a text, a laboratory manual, a detailed teachers guide, ten specially designed teaching films, programmed instruction in chemical arithmetic, and objective multiple choice unit, mid-year and final tests. All these materials emphasize the way a chemist works; he makes observations and experiments, systematizes these observations, uses imagination to create models to account for these observations, and communicates his findings.

There is a big difference in the general level of science at the school stage of this country compared with that in the more advanced countries and it is necessary to rectify this lag The only way of upgrading the present low standards is to make a break-through by dropping out the non-essentials from the existing syllabi and make time available for more important basic principles and modern concepts, so that no part of what is taught at the school stage need be untaught at a higher level, as is unfortunately the case at present During a detailed discussion of this aspect by the participants with the Chairman and some members of the S.S C. Board, Poona, the urgency was stressed for (1) redrafting the syllabi wherein not only the contents are rearranged, but the emphasis is shifted to the experimental approach, and (2) for changing the present system of examination, so that between 25-50 per cent importance is given to direct, objective tests and the class record of work of the student to be maintained by the teacher

Participants discussed plans to put the CHEM-Study ideas into their classes in the coming year They further explored ways of exchanging information about their success in using CHEM-Study materials with Indian secondary school students.

B. EVALUATION

By Members of the Coordinating Committee

The Chemistry Institute was a fine institute in every respect The new materials were carefully examined by the faculty and the Institute was carefully organized to test out these materials. The materials included the CHEM-Study Text, the Student Laboratory Guide, and the Teachers Laboratory Guide, which were furnished to the participants The ten films completed for use with the CHEM-Study programme were also made available and used in the programme. The Director had hoped to include one or two high school students along with the teachers to see how they responded to the new materials, but was unable to do so at the beginning The ones who joined late responded with keen interest in the programme.

At first too many pre-laboratory directions were given, thus limiting the joy of discovery on the part of the participants. This was corrected, however, and everyone was able to see the advantage of using the laboratory to investigate something that is not known and then coming back together proving results and finding what new information, what new conclusions could be derived from the results of the experiments. This exciting new way to study chemistry as an experimental science is one of the experiences which will be taken home and practised by the participants in their teaching of chemistry. Though we were unable to furnish all of the participants sets of the teachers guides and resource books, these will be sent to them as soon as more copies become available. From conversations with both the faculty and the participants, it becomes clear that most of them believe that much of the new approach and some of the new content may be introduced into the chemistry programmes as they now exist. Many of the participants, however, expressed the desire to have freedom to experiment further than they believe can be done in the present syllabus and examination system It seems clear that much of the material and the new approach of the CHEM-Study Programme may be used to advantage in modernizing the teaching of chemistry in India

By Dr Donald D Starr, Visiting American Scientist

The results of this first Chemistry Institute to be held in India were most gratifying. Admittedly the teachers pointed out their handicaps, a rigid syllabus, an external examination system, and poorly equipped laboratories, not to mention overcrowded classes and overworked instructors, but an interesting change developed over the eight weeks with most of the teachers. They began to see the validity of this new strategy in approaching the teaching of chemistry as an experimental science—letting the students do the experiment first and then developing the needed explanations to enable them to understand why the chemical systems they observed acted the way they did. In short, most of them came to the perspective that "chemistry is what chemists do" and students in their first course in chemistry should get this exciting feeling that comes from participating in a movement of inquiry—the essence of science.

"These CHEM-Study materials in English will have great usefulness at the pre-degree—first full year of a four-year B.Sc. programme after the 11th standard-level here in Maharashtra State and perhaps elsewhere.

"This type of Chemistry Seminar should be repeated and expanded to several universities throughout India for a greater number of chemistry teachers."

By Participants

Thirty-one of the thirty-eight participants in the Chemistry Institute responded to a questionnaire Below are summarized their responses to four questions A tally was made of the frequency of a particular response Each tally refers to the number of participants indicating a particular idea The responses have been categorized topically. Responses to the four questions were as follows:

I In view of the purpose of the Summer Seminar to up-grade secondary school science education, which experiences in your Summer Seminar do you value most? Why?

The Approach

(a) The subject-matter approach of the CHEM-Study books—8

(b) Pupils have to understand more, memorize less. Avoids burden of unnecessary useless details—5

(c) Descriptive part is used to a minimum while stress on process involved is maximum—4

(d) The introduction of modern concepts of atomic structure, energy changes, and the periodic table will be helpful to the students to understand the subject without any burden on memory—3

(e) Treatment of subject is on particle model. Unimportant things are omitted Within a short period of time, a student can understand much of chemistry—3

(f) Have been enriched by the approach which differs totally from the old approach—3

(g) Thinking and reasoning on the part of students is given more importance, and chemistry as only memorization is done away with—3

(h) The most advanced developments are explained very clearly such that a high school pupil can understand easily—1

(i) Coming to know the chemistry material opened my eyes to the new approach of purposeful teaching of chemistry in the modern context of an evergrowing knowledge of science and technology—1

(j) While teaching, we should delete the unimportant details and concentrate attention on the main points. While dealing with chemical equations, this principle must be used It would save time and energy—it could be called a "break through" which was one purpose of the seminar—1

(k) Method of study is experimental—1

Bringing up-to-date

(a) Presenting up-to-date information on physical and organic chemistry with only necessary mathematics—6

(b) Demonstrations by teachers provoke thinking, observation, interpretation, and application of the concept—1

Experimental Method

(a) The emphasis on the practicals and the teaching of the subject by the observation of simple experiments leading to generalization—3

(b) The practical training that I got is the most valuable because this has trained my own hand and it is likely that I may utilize this practical skill for the uplift of my own students—2

(c) Practicals are well arranged, particularly experiments in qualitative analysis and candle burning—2

(d) Various correlations between the theory and practical—3

(e) Chemistry is an experimental science Practical work is entirely based on student observation and experimentation—2

(f) We did the practicals ourselves. More and more experimental work should be given to the students—2

(g) Experiments are so simple that they can be performed easily with minimum available material and equipment—1

Demonstrations

(a) The two lectures delivered by Dr Campbell and his model lessons—4

(b) Demonstrations by the teachers provoke thinking, observation, interpretation, and application of the concept—1

Evaluation

(a) Evaluation is on basis of understanding—4

(b) Memory testing is to be avoided—1

(c) Achievement tests are useful in a number of ways, for example· (i) the short duration of examination, (ii) quick answers, (iii) quickness in examining papers, (iv) correction afterwards, (v) for showing clearly major and minor concepts—1

Films

(a) The films shown were educative and interesting—4
(b) The use of films helps much in understanding physical chemistry and chemical reactions—1
(c) Films help a lot to make the subject easy—1
(d) The films—they were simply enchanting, especially the ones on inert gases and halogens, and on molecular structures and their spectra—1

Discussions

(a) Mutual exchange of ideas and experiences—3
(b) Discussions helped me to understand the different aspects of science teaching and to share my ideas with others and to clear my doubts—2
(c) Knowledge of the type of education in a country like the U.S.A. and the comparison and contrast of the opportunities available—1

II. Using the present syllabus, can you see ways to introduce new content and new approaches in your classes? To what extent can you do this? Give an example

Quantitative Responses

(a) Yes, with the qualifications listed below—27
    (i) All of it—1
    (ii) Closely correlated 50%—2
    (iii) Content and approach 40 to 50%; Practicals 40%—1
    (iv) To a limited extent 30%—1
    (v) 25%—1
    (vi) No, not at all—4

Qualitative Responses

(a) The new content can be easily introduced using any syllabus in the world—1
(b) Yes, most of the topics can be included—3
(c) Yes, new content and new approaches may be included—2
(d) Using the same syllabus and examination system, it will be very difficult for a teacher to introduce the new approach—1

Method Responses

(a) For the chapters of the text covered in the syllabus, I can teach better by experiments and demonstrations For the chapters not covered in the syllabus, I shall correlate with the other chapters—1

- (b) Yes I can teach the new programme in the elective system—3
- (c) We can follow the methods, models, and film shows to improve the understanding of our students—1
- (d) When we teach acid—base reactions, we can give them modern ideas behind it—1
- (e) We can give the demonstrations only—1
- (f) Instead of teaching in connection with the syllabus, I will try my best to give much of the materials to the students through the science club—1
- (g) I will use the new materials in group discussions and in the science club meetings after school hours—2

Particular Content—Topics Specifically Mentioned

- (a) Physical and inorganic portions—1
- (b) Yes The first eight chapters can be covered. I shall prepare a schedule and let you know—1
- (c) Atomic structure—8
- (d) The periodic table Utility in different experiments will reduce rote memorization—4
- (e) Acids and bases—8
- (f) Oxidation and reduction—8
- (g) Chemical reactions, chemical calculations—4
- (h) Electron reactions—4
- (i) Tests of anions and cations—2
- (j) Rates of chemical reactions—1
- (k) Equilibrium in chemical reactions—2
- (l) Burning candle reactions—2
- (m) Valency—2
- (n) Molecules in physics as well as in chemistry—1
- (o) Nuclear approach—1

III If you believe in the approach to learning, you experienced in this seminar, how do you plan to help others to become aware of it?

Plans to use with students

- (a) I shall have to make some experiments and see what can be done—3

(b) To try it on an experimental batch of pupils—1
(c) By arranging science fairs and showing some of the interesting experiments—1

Plans to use with teachers in my own school

(a) I shall share my experiences and materials with my colleagues through a study circle—7
(b) By group discussions—2
(c) By loaning my set of books to the other teachers—2
(d) Will use faculty meetings to make others understand the new approach to certain topics—1

Plans to inform teachers in other schools

(a) By talking to my colleagues—3
(b) By organizing local seminars—7
(c) I shall invite neighbouring teachers to observe work being done in my school—2
(d) I may go to other institutions and demonstrate these experiences—3
(e) By arranging lectures about this experience—5
(f) By having some type of seminars on the district level—6
(g) I shall share my experiences and the materials through the secondary school teachers association—3
(h) A newsletter should be started in which reports of progress can be made—1
(i) I shall write some articles for journals—2
(j) I may even try to translate the materials into my regional language—1
(k) We should try to translate the CHEM-Study tests into the regional language—1

IV State some practical suggestions for improving Summer Science or Mathematics Seminars in the years ahead.

Suggestions Concerning Programme

(a) There should be discussion about what things could be modified to suit the Indian situation—4
(b) Demonstrations of teaching should include processes, ways and means, aids and other material required for actual teaching work in our schools—2

(c) Some demonstration lessons should be arranged by expert teachers using new materials to convince participants that new approach can be as effective in teaching the principles as the old approach—5

(d) A batch of students in the seminar would provide better training for the teachers—2

(e) Seminar should be held when schools are at work—1

(f) There should be more discussions at end of lectures and practicals These should be made stimulating—3

(g) Results of discussions should be reported by fortnightly bulletin—1

(h) Programme should be planned well in advance of seminar—2

(i) More films should be shown These are most helpful in imparting knowledge—3

(j) More emphasis should be laid on the construction of models and inexpensive materials—1

(k) Study of course should go systematically right from first chapter—2

(l) Practical work suggested for each chapter should go side by side with chapter, also films—2

(m) Since teachers are graduates and some post-graduates, there should be emphasis on self-study and group discussions—1

(n) Stress should be laid on practical aspects, not lectures—3

(o) Observations and conclusions of all experiments should be discussed by the whole group—1

(p) Methodology of approach in the classroom will aid participants—1

(q) More stress on methods of teaching by actually assigning lessons—1

(r) Achievement tests should be administered immediately after the study of a group of chapters—1

(s) Achievement tests should be constructed by participants—1

(t) More library facilities should be given—1

(u) Have "popular talks" on modern current topics of scientific advancement—1

Suggestions Concerning Staff

(a) There must be an expert in education on the staff. He will be able to suggest method of transfer of knowledge

to young boys in a better way—4
(b) Teachers from training colleges should be invited to discuss the new approach—4
(c) More American experts should be called These should all be experienced in the new material—3
(d) Some such teacher from U S A should be sent to participate who has actually carried out this type of experimentation in schools—3
(e) Teachers from different universities who have specialized in the different sections of the subject should be entrusted to deal with different topics—2
(f) Staff should share lodging and boarding with the participants This will bring about good intimacy between them—1

Time and Place Considerations

(a) Organize seminars at state level or area-wise so that more teachers can be benefited and less expense incurred—1
(b) Hostels should be near the lecture-lab situation—1
(c) Period of seminar should be one month—1
(d) Site of seminar should be away from cities—1
(e) When participants are in a seminar for a long time, some recreational arrangements should be made to lessen boredom and keep it ever interesting—1

Other Suggestions for Improvement

(a) Let the present participants have a chance to participate in the next year seminars They can offer their experience as follow-up—2
(b) Only teachers engaged in teaching elective science should be called for seminar for some time—2
(c) Participants should come only from higher secondary schools and multi-purpose schools—1
(d) Apart from regular application, there should be a questionnaire or interview for the applicants regarding science teaching, so that only those interested may be chosen—3
(e) Let more teachers be benefited by such seminars—2
(f) Some participants should be given more advanced training to be better advocates of CHEM Programme—1
(g) Some participants should be selected from B.T training colleges—1

(h) Necessary literature should be in the hands of participants ahead of time—4
(i) Participants should be informed at least 15 days to one month before the date of seminar—2
(j) We should use our syllabus as a start, discuss ideal situation, and prepare text in cooperation—1
(k) Send texts at least two months in advance to those who are selected Engage local professors to give lectures and some experiments Then participants can convene and have much shorter seminars—1
(l) Introduce CHEM-Study in a few experimental schools and watch the results—1
(m) Examination system should be changed—1
(n) Medium-wise seminar should be conducted, e.g., different language media in different seminars—2
(o) If speeches of eminent teachers in the field were put on tape, participants could get a chance to reproduce them in the hostels—1
(p) There must be some committee to supervise as well as encourage and aid in the follow-up programme—2

*By G Y. Dixit (a participant)**

Reactions of the Participants

The participants of the seminar in Poona had the third edition of the text for review and study. The participants at first felt that the standard of the text would be too high for the students of their schools. But after careful reading of one chapter after another, however, the apparent reactions against the text yielded to passive appreciation and finally to active consideration of how best it could be worked out for Indian students.

Approach of the Text (Dynamic and Practical)

CHEM-Study approach is radically different from the traditional one. The latter gives more stress on the description of elements and their compounds—their occurrence, manufacture or preparation, properties and uses—while the former emphasizes the processes involved in chemistry. The knowledge in chemistry, as also that in other sciences, is growing at a fantastic rate and it is nearly impossible to

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*Extract from article entitled, "Summer Seminar in Chemistry Study," *Progress of Education*, 37, (12) . July 1963 encompass it in one single textbook in chemistry Hence, if the subject is to be studied, it must lay more stress on the universal concepts rather than on just describing the enormous knowledge acquired after patient research This is certainly a bold and compelling approach which no nation desirous to be up-to-date in science can afford to neglect The CHEM-Study has grasped this approach and is trying to work it out for the benefit of the future generations of the world

The method of acquainting students with this course is that of experimental study of different topics together with class demonstrations by the teacher Students have to perform a number of experiments from which they have to deduce conclusions. It is interesting to note that these experimental results are embedded in the discussion of the text-matter Thus, there is a well-calculated coordination between theory portion and practical work

From the foregoing account, it will be clear that this is not the chemistry that we are teaching to secondary school children in our country A very thought-provoking question before the participants of the seminar was. "Why should we not teach chemistry in this way (and also, how can we introduce it in our schools)?"

Some Significant By-Products

The seminar offered a very good opportunity for the secondary school teachers of various States to discuss the educational patterns that exist in various schools It was rather strange to find that different patterns of secondary education exist in the States of India. All the participants felt that there should be a uniform pattern for education if all have to cooperate to evolve a better syllabus in this subject which is in many cases taught in regional languages as well as in others, for the whole nation.

All the participants appreciated the utility of such a Summer Institute. Such an activity undoubtedly refreshes their knowledge about the subject and also gives them the benefit of discussions about the problems of education. An exchange of ideas and broadening of views are the desired benefits, lending a new outlook

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SUMMER INSTITUTE IN PHYSICS UNIVERSITY OF DELHI

R C MAJUMDAR*

The Summer Institute was inaugurated by Dr D S. Kothari on May 14, 1963 Regular work started from May 15, and continued to July 13, 1963 Forty-two teachers from different parts of India came to participate in the Institute

As regards the course of lectures given to the participants, it was decided by the Director, after meetings with the staff members of the University Physics Department, the representatives of the University Grants Commission, and the representatives of Columbia University (U S.A.) associated with the Institute, that it should be divided into two categories, one dealing exclusively with the higher secondary syllabus, and the other with modern developments in physics. The lectures in the first category were essentially of the nature of seminars in which school teachers had thorough discussions on the fundamentals of their subject and the difficulties associated with presenting it in an effective manner to the students They were also designed to impress upon the participants the changing trends in physics teaching all over the world on account of the vast expansion of the subject in the last few decades and the need to cope with this expansion. In this connection, the Physics volume prepared by the PSSC (USA) serves an admirable purpose; it was, however, felt that this textbook could not be fully adopted in our schools, primarily because of its too qualitative a character. The standard of the physics course in our schools must necessarily be such that it makes for a smooth transition to the university stage.

The second category of lectures (dealing with recent developments in physics) was considered necessary in order to give to the participants a glimpse of the important new discoveries in the subject, and thereby arouse their interest in the study of some of them. This, it was hoped, would not only make for greater efficiency in imparting instruction but also provide variation from the monotony of routine work

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*Dr. R C. Majumdar is Professor and Head of the Department of Physics, Delhi University, Delhi.

Topics included in the two categories of lectures and the number of lectures in each are given at the end.

As in the case of theory lectures, laboratory work for the participants was also divided into two classes (i) Simple elementary experiments that could be built out of the kits supplied by the U.S. A.I.D., and (ii) Advanced experiments. The advanced experiments were introduced because it was felt that in addition to knowing the simple, semi-quantitative kit experiments, the participants at the Institute should also have some familiarity with the refined types of apparatus used for highly accurate measurements, and with the modern novel techniques employed in experimental Nuclear Physics and Elementary Particle Physics. A list of the advanced experiments follow.

A number of lectures on the methodology of physics teaching had also been arranged. Instructive films demonstrating certain basic principles of physics were shown to the participants almost every day. A list of films follow at the end of my report.

The participants received training in workshop practice in the University workshop. Here, each one of them duplicated six of the kit experiments. These duplicate kits and also some of the kits purchased locally were taken by the participants to their respective institutions. Arrangements were made for the participants to visit the National Physical Laboratory, the Indian Agricultural Research Institute, the Meteorological Observatory and the All India Radio Television Studio.

The participants were housed in the Gwyer Hall of the University, each occupying a single room with a fan. Arrangements for their breakfast, lunch and dinner were made in the Hall itself. Every effort was made to make their stay comfortable.

Principles of Physics	8 lectures.
Story of Electrons	6 lectures
Dimensional Analysis and Theory of Errors	6 lectures
Physics of the Nucleus	6 lectures
Atomic Physics	12 lectures
Electricity and Magnetism	14 lectures
Elementary Particles	8 lectures
Super fluidity and Super-Conductivity	6 lectures
Sound and General Properties of Matter	8 lectures

Mossabauer Effect and Parity	6 lectures
Optics	10 lectures and 4 seminars
Heat and Thermodynamics, and Physics of the Cosmos and Plasma Physics	12 lectures
Methodology of Physics Teaching	10 lectures
Mechanics	5 lectures

Advanced Experiments

1. Elastic constants of glass by Cornu's Method.
2. K by Lee's method.
3. Michelson Interferometer, for Na or Hg lines, and 'd' for Na yellow lines.
4. Hg-spectrum constant deviation spectrometer.
5. Biprism; thickness of a mica sheet.
6. Magnetic susceptibility by Quincke's method.
7. Triode Characteristics.
8. Thyratron.
9. Hall effect.
10. Spart counter. Range of sign particles
11. Characteristics of a G.M. Counter and absorption of sign rays.
12. Millikan's experiment; determination of e.
13. Determination of e/m.
14. Scintillation spectrometer.
15. Investigations of elementary particles by emulsion technique.

PSSC Physics Films

Part I — The Universe

1. Time and Clocks
2. Short Time Intervals
3. Long Time Intervals
4. Measuring Large Distances
5. Measuring Short Distances
6. Measurement
7. Change of Scale

8 Straight Line Kinematics
9. Vectors
10 Vector Kinematics
11. Definite and Multiple Proportions
12. Elements, Compounds and Mixtures
13. Crystals
14. Behaviour of Gases

Part II — Optics and Waves

1. Introduction to Optics
2 Pressure of Light
3 Speed of Light
4 Simple Waves
5. Sound, Waves in Air

Part III — Mechanics

1. Forces
2. Inertia
3. Inertial Mass
4. Free Fall and Projective Motion
5. Deflecting Forces
6. Periodic Motion
7 Frames of Reference
8. Solar System Kinematics
9 Universal Gravitation
10. Elliptical Orbits
11. Energy and Work
12. Mechanical Energy and Thermal Energy
13. Conservation of Energy
14. Collision of Hard Sphere
15. Elastic Collision and Stored Energy

Part IV — Electricity and Atomic Structure

1. Coulomb's Law
2. Millikan Experiment
3. Coulomb's Force Constant
4. Electric Fields
5 Electrical Lines of Force
6. Counting Electrical Charges in Motion

7. A Magnet Laboratory
8 Electrons in a Uniform Magnetic Field
9 Photo-Electric Effect
10 Photons
11 Electrical Potential Energy (Part 1)
12 Electrical Potential Energy (Part 2)
13 Matter and Waves
14 A Million in One
15 E. M. F.
16 Elementary Charges and Transfer of Kinetic Energy
17. Rutherford Atom
18 Frank-Hertz Experiment
19 Mass of the Electron
21 Interference of Photons
20 Electromagnetic Waves

B EVALUATION

By Members of the Coordinating Committee

The Summer Institute in Physics, 1963, at the Physics Department of the University of Delhi was planned to stress a review of advanced physics courses and lectures describing recent developments and research Less than half of the time was spent teaching the PSSC course.

This Institute was somewhat longer than the other Institutes, being of 9 weeks duration because of the extensive content presented. The content of the traditional portion of the Institute was given in lectures and in laboratories using high precision university physics apparatus.

The materials for the entire PSSC Physics programme were provided. Each participant was given a PSSC Physics text, a four volume Teacher's Resource Book and Guide set, a student Laboratory manual for physics and several of the 24 volumes of physics reference books. The entire set of 54 physics experiment films and 10 complete sets of laboratory kits were available Although nearly all of the PSSC laboratory experiments were done, the use of the remainder of these available resources was limited largely to the sections studied by the PSSC approach.

Many of the students never absorbed the spirit and philosophy of the PSSC course, they did not follow the approach of going to the laboratory to experiment in an investigatory manner, and then developing conclusions from these experiments in discussions and seminars

However, all the participants were extremely enthusiastic about the new laboratory programme They approached the new experiments with curiosity and an eagerness to learn by the exploratory method Almost all the participants appreciated the depth and cleverness of the seemingly simple experiments Out of 52 PSSC experiments, 40 were completed.

The workshop programme also was a great success. Here each participant was given the basic materials and taught how to make six pieces of the new apparatus that were introduced through these PSSC experiments These were the ripple tank, the straw balance, the stroboscope, the recording timer, the "refraction of particles" simulation, and the range finder

One participant remarked, for example, that a practical syllabus based on use of apparatus made by students themselves will be infinitely more beneficial than one based on intricate factory made machines, for indeed, making of an apparatus itself enlightens the students, for example, one who spends a few minutes in making a Soda Straw balance discovers for himself the law of moments.

Approximately 20 of the 54 PSSC experiment films that were available were shown. These were the films related to certain sections of the PSSC text:

Part I—The Universe—Chapters 1 to 6 only
Part II—Optics and Waves—All 9 chapters
Part III—Mechanics—Chapters 20, 23, 24 and 25.

The outline of the content of the PSSC Physics text and the list of Student Laboratory Experiments is given in the description of the PSSC Physics Programme, Part I, item 2 of this report.

It was only in the study of Part II, Optics and Waves, that the participants experienced the unified approach of the PSSC Programme—where the laboratory and experiments on films were used in connection with class discussions, seminars, lectures, and the use of the text and the PSSC library of resource books in physics

For future institutes, it is suggested that there should be only a limited number of lectures on recent developments in physics, and that too of a standard which could be understood by the participants. A unified programme, such as the PSSC Programme or a modification of it adapted to the background and skills of Indian students, should be followed in future Institutes

By Dr Kenneth Baker, Visiting American Scientist

I address my remarks in this report chiefly to those colleague physicists who have been associated with this first experimental effort at Delhi, and to Dr. Kothari and other members of the Indian University Grants Commission who have made the Institute possible The remarks of course apply only to the Physics Institute.

I came to India uninstructed knowing only that Physics PSSC Summer Institute was in session. Admittedly, six weeks is all too short a time to become well informed. Nevertheless, I have made observations and drawn conclusions I hope they will be of some aid to you in your further decisions. I offer them because physicists throughout the world have a common desire for good physics If we are to have good physics, then we must have up-to-date training, enthusiastic teachers, and a steady supply of students sincerely interested in physics

The Physics Institute at Delhi

A complete set of PSSC materials including textbooks, guides, films and laboratory equipment was provided for the forty-two participants in the Institute Approximately 33 per cent of the scheduled lecture time (including the reduced time available in June) and 50 per cent of the practical (laboratory) time was available for PSSC training. The remainder of the participants' time was spent on special lectures Twelve different lecturers are listed on the schedule and at least one additional lecturer actually appeared. The average number of lectures per lecturer was, therefore, roughly eleven.

The Revision of Science Teaching

I know at this time of writing that India has decided to write a new textbook for secondary school physics. This, coupled with the existence of the present institutes indicates an intention to make changes in secondary school science teaching.

A change in science teaching requires more than a new textbook. It requires the revision of laboratories (i.e. "practicals"), the design of laboratory equipment, the manufacture of laboratory equipment, the preparation of supplementary material for students, the preparation of aids for teachers, the revision of curricula, and a study of testing procedures.

Possible Courses of Action

One way of revising secondary school science would be to adopt a unique Indian approach. A unique Indian approach (understandably desirable in an emerging nation) will require time, great effort, and money. If India decides to follow her own course then summer institute should be organized only when at least the preliminary versions of all facets of the new material are available.

I strongly recommend that if an Indian approach is to be made, then, for example in physics, outstanding young physicists and outstanding secondary school teachers should be encouraged to shoulder the major portion of the task.

A second way of revising secondary school physics would be to adopt a complete PSSC approach. A completely American approach would be at once easy and again difficult. It would be easy in the sense that adoption of PSSC Physics would mean that the difficult, detailed, planning and development could be avoided. Much saving of time, effort and money could be effected. The problem of the manufacturing (but not the designing) of laboratory equipment still remains, since currency restriction prevents its purchase from America. A further difficulty of spreading the material over three years in Indian schools should not be inhibiting since school time available is apparently less, the PSSC text is long, and extra chapters are already in print, or there is no reason why this material could not simply replace present class XI physics.

A third possible approach would be to use an Indian textbook and PSSC type equipment. This "combined" approach is dangerous because it is very likely to be uncoordinated. Attractive though this approach might appear, I believe it should be avoided. Summer Institutes would be of little help until, again, the total programme has been completed.

If India feels, or if Indian physicists feel, that revision is urgently needed (and a strong sense of urgency is particularly evident among the 42 secondary school teachers and among some of the university staff, I have met) then a decision on what is to be done must be made Naturally, I am prejudiced toward the PSSC point of view But chiefly because I feel Indian physics needs it and every year of delay affects a year's production of students, and postpones the hope of modern developments in all of Indian physics

Once the decision is made on what is to be done, then the purpose of the Summer Institute can be determined If the decision for PSSC Physics is made, then Americans can be of great help.

The Purposes of a PSSC Physics Summer Institute

In a PSSC Physics Summer Institute, the participants are literally "led by the nose" through the PSSC material Only if this is done, can they succesfully teach it the following year

Advanced lectures are held to a minimum and are coordinated precisely with the material in the text For example, an advanced lecture on the theory of error can occur at the time significant figures are discussed, or the mathematical determination of the energy criteria for possible orbits in an inverse square force field can form an advanced lecture or two when Rutherford scattering is discussed in class.

All problems in the text are solved by or discussed with the teachers Not only do these problems extend their knowledge but they are designed to make them think, rather than numerically evaluate variables in rote formulas.

Careful attention is paid to the practicals They often must be done before the student (teacher) meets the material in class The stress is on observation first, speculation later, not definition first and numerical substitution later

In short, in a PSSC institute the majority of a participant's time, perhaps as much as 85 or 90 per cent is spent on PSSC materials, textbook, and approach

By Participants

Thirty-nine of the forty-two participants in the Physics Institute responded to a questionnaire Below are summarized their responses to three questions A tally was made of the frequency of a particular response Each tally refers to the number of participants indicating a particular idea Single responses or irrevelant responses were omitted The responses have been categorized topically. The responses to the three questions were as follows:

I In view of the purposes of the seminar to upgrade secondary school science education, which experiences in your summer seminar do you value most? Why?

The PSSC Programme

(a) The laboratory using the PSSC inexpensive equipment—36
(b) The PSSC course as presented in the text and in lectures—15
(c) The PSSC films of physics experiments—7
(d) The workshop where PSSC equipment was made—2

The Traditional Physics Programme

(a) Lectures in Advanced Physics—8
(b) Laboratory experiments using precision instruments—1

Visits to Scientific Institutions

II Can the practicals you have experienced this summer be used in your classes? To what extent can you use them? Give an example.

The Frequency of Yes, No and To Some Extent Responses

(a) All the PSSC experiments can be used—17
(b) None of the PSSC experiments can be used—8
(c) Some of the PSSC experiments can be used—14

Examples of Experiments that Can Be Used Cited by Respondees in (c) above

(a) Short time intervals
(b) Large Distances
(c) Motion—Speed and Acceleration
(d) Small Masses
(e) Reflection from a Plane Mirror
(f) Images formed by a Concave Mirror
(g) Refraction
(h) Images formed by a Converging Lens
(i) Pulses in a Ripple Tank
(j) Periodic Waves
(k) Refraction of Waves

(l) Waves and Obstacles
(m) Waves from Two Point Sources
(n) Interference and Phase
(o) Changes in Velocity with a Constant Force
(p) The Dependence of Acceleration on Force and Mass
(q) Momentum Changes in an Explosion
(r) The Cart and the Brick
(s) Slow Collisions
(t) Changes in Potential Energy
(u) The Energy of a Simple Pendulum
(v) A Head-On Collision
(w) Electrified Objects
(x) The Mass of the Electron

III. State some practical suggestions for improving summer science or mathematics seminars in the years ahead

1. Advanced information about the courses should be provided to the participants—22
2. There should be small group seminars in which the participants may interact with faculty—11
3. The instruction in the institutes should be in accordance with the present secondary school syllabus—9
4. The programme of the institute should be limited to the PSSC programme only—5
5. More time should be spent in the workshop making the PSSC apparatus—11
6. The institutes should be organized on a regional basis rather than on an all-India basis—6

In summary it may be said that the PSSC Physics programme with its new approach, content, experiments with simple apparatus, experiments on film and its library of resource books were preferred by the participants.

Some of the participants were of the view that all of the PSSC experiments can be employed in high school teaching. However, consensus of opinion was that unless the present high school syllabus is revised in the light of the new PSSC approach, the chances of including many of these experiments is slim.

It is needless to say that the participants enjoyed the Summer

Institute and want to be a part of similar institutes in the future in one capacity or another Some suggested that they should be included in future Summer Institutes as faculty; others that they should become a part of the staff of some of the regional colleges.

By a Participant

The science curriculum is bookish and theoretical. It is overcrowded without providing rich and significant content. Curriculum is to be arranged in order to make provisions for practical and other activities that the pupils may become active participants in the learning of science

The using of simple and cheap apparatus modelled by the PSSC scheme will help science teaching very much. The apparatus is so simple and the materials which go into the function of them are so inexpensive that every school can afford to have a good stock of scientific materials with less investment

This Seminar in Physics is a great success With a little more of planning and changes suited to the requirements of actual science teaching and methods of science teaching, this seminar would prove better Here, we the participants of the seminar are getting up-to-date and detailed information about this subject, theoretical as well as practical As the participants are gathered from different parts of India and as they are housed comfortably in the same campus, we are having a rare and golden opportunity of discussing the problems and conditions of science teaching in various States. Such seminars will surely help the teachers a long way to have an understanding of the real problems in science teaching

12

SUMMER INSTITUTE IN MATHEMATICS RAMJAS COLLEGE

R D GUPTA*

This Summer Institute was a unique educational project in the sense that it was the first experiment of its kind in which teachers from schools, colleges and universities made a concerted and combined effort to reorient the curriculum and methods of teaching mathematics Mathematical instruction in our schools has remained static for decades and we are at least fifty years behind the times This time lag, if allowed to continue, is likely to hamper our progress in the fields of science and technology There are certain basic concepts, the understanding and appreciation of which are essential to the development of mathematical education from the earliest stages. These have to be stressed at every appropriate occasion through the school course so that the attitude towards mathematics may be in keeping with the modern spirit of the subject This will involve a complete overhauling of the school syllabi, preparation of suitable textbooks and other reading material and refresher courses for the teachers. This Institute was intended to meet these requirements

The principal objectives of the Institute were

i) to improve the subject matter competence of the participating teachers,

ii) to give teachers a better understanding of some of the basic concepts of modern mathematics,

iii) to strengthen the capacity of the teachers for motivating able students to develop an aptitude for research,

iv) to stimulate the interest of teachers by bringing them into contact with prominent men in the field of their study,

v) to promote greater understanding and appreciation of each other's teaching

vi) to increase their skills as teachers and their ability to inspire their students.

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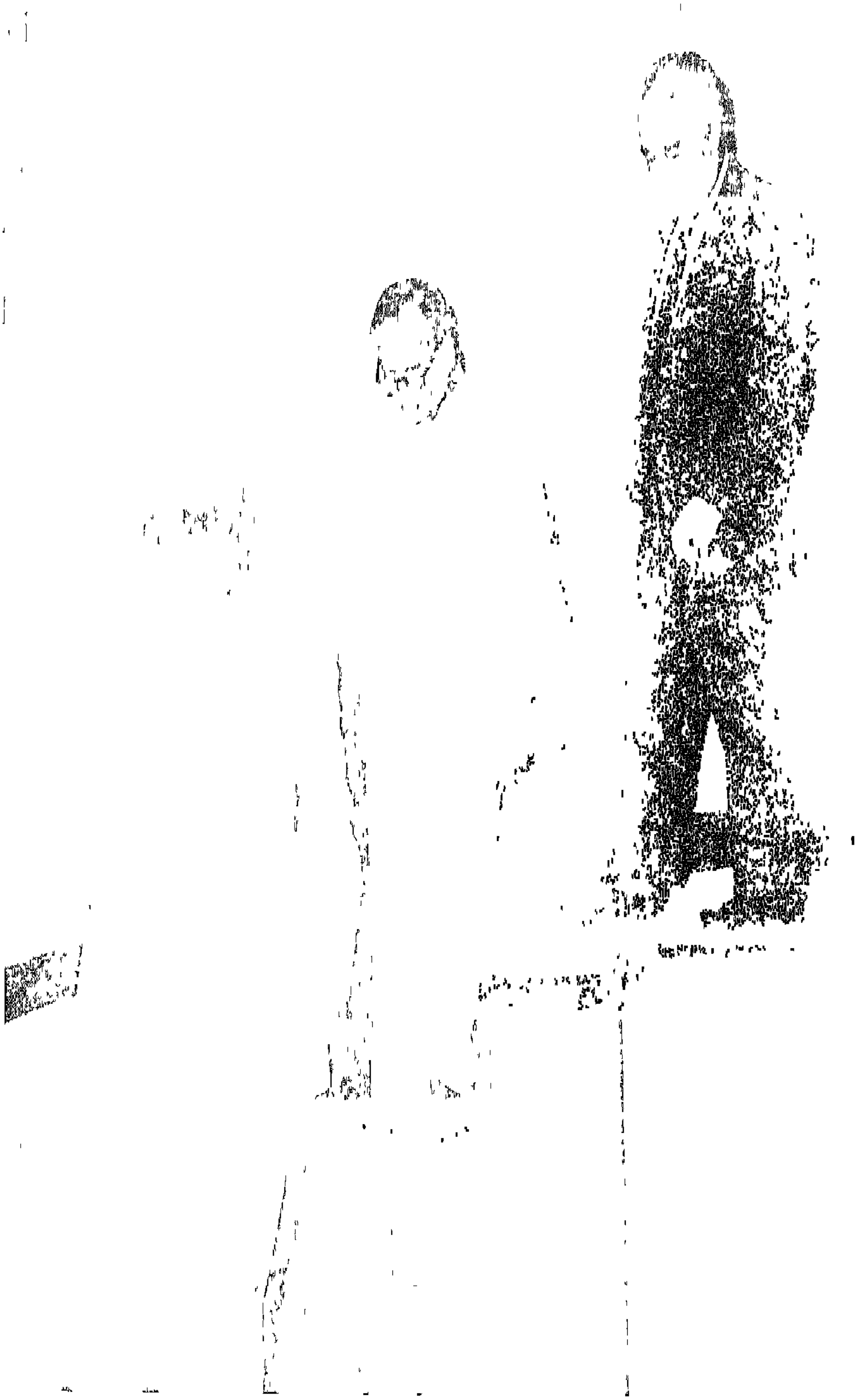
*Dr. R. D. Gupta is Principal of Ramjas College, Delhi University, Delhi.



Dr. K. L. Shrimali, Education Minister, visiting the Mathematics Institute

Inauguration

The Institute was inaugurated on May 16, 1963 by Dr K L Shrimali, the Honourable Minister for Education, Government of India Dr D S Kothari, Chairman University Grants Commission, presided.

Dr Shrimali in his inaugural address called upon the delegates to discuss and ponder over various problems of mathematics teaching. In particular, he pointed to the large number of failures in the subject and wished that an institute like this could think over this problem and suggest improvements in the teaching methods to remedy it

Prof R. S. Varma, Head of the Department of Mathematics and Statistics, University of Delhi, stressed the need for reorienting the teaching of mathematics in schools Prof Ram Behari, DR J. Paul Leonard and Principal Shanti Narayan also spoke on the occasion

THE PROGRAMME

Institute Lectures

Courses of lectures were arranged on various topics, two lectures of 75 minutes each being held every day The lectures were followed by useful and lively discussions.

	Name of the Lecturer		Topic	No. of lectures
1.	Dr. E P Starke, Professor Emeritus, Rutgers, The State University, New Jersey, U S A.	i)	Introduction to Probability	6
		ii)	Introduction to Real Functions	7
2.	Shri Shanti Narayan, Principal, Hans Raj College, Delhi	i)	Set Theory	3
		ii)	Algebra	8
		iii)	Geometry	7
3	Prof J N. Kapur, Head of the Department of Mathematics, Indian Institute of Technology, Kanpur.	i)	Nature of Mathematics	3
		ii)	The Applications of Mathematics	4
		iii)	Basic Concept of Statistics	2

4.	Shri D. B Gupta, Lecturer in Economic Statistics, Ramjas College, Delhi.	Statistics	6
5	Shri J. D. Gupta, Lecturer in Mathematics, K. M. College, Delhi.	i) Vector Algebra ii) Trigonometry	3 1
6	Shri Sahib Singh, Lecturer in Mathematics, Institute of Post-Graduate Studies, University of Delhi, Delhi	Theory of Numbers	5
7.	Shri Mohan Lal, Head of the Department of Mathematics, P. G. D A. V. College, Delhi.	Geometry	3
8	Shri P. D. Gupta, Principal, Ramjas College, Delhi.	Geometry	3
9	Dr. M. K Singal, Lecturer in Mathematics, Ramjas College, Delhi.	i) Number System ii) Matrices iii) Boolean Algebra	3 6 2

Special Lectures

The following special lectures were arranged :

1.	Prof. Ram Behari, Director, Correspondence Courses, University of Delhi, Delhi.	Non-Euclidean Geometry
2.	Prof. R. S. Varma, Head of the Department of Mathematics and Statistics, University of Delhi, Delhi.	Need for a new approach to teaching of Mathematics at different levels

3	Prof U. N. Singh, Head of the Department of Mathematics, Baroda University, Baroda.	Rigour in Mathematics
4	Dr D N. Misra, Reader in Mathematics, University of Lucknow, Lucknow.	Set Theory
5	Dr I. N Sinha, Reader in Mathematics, University of Bhagalpur, Bhagalpur.	Importance of Pure Mathematics
6	Dr A. C Choudhary, Reader in Mathematics, University of Calcutta, Calcutta.	The Spirit of Modern Mathematics
7.	Dr. N E. Bingham, Science Education Consultant T. C. C. U. Team, U S.A I D	Summer Institutes in the U.S.A.

Group Discussions

A discussion period extending over one hour and a half was a daily feature of the Institute. In addition to discussions on lectures the material from S.M S G. books on various topics was also discussed in detail Some of the topics on which discussions were held were :

a) *Algebra*

Factors, Radicals, Polynomials, Rational Expressions, Truth sets of open sentences, Polynomials in two variables, Systems of open sentences, Quadratic Polynomials, and Functions.

b) *Geometry*

Definitions of lines, segments and rays etc., angles, and congruence.

c) *Others*

Teaching of Arithmetic in Secondary Schools, Teaching of Algebra in Secondary Schools, Teaching of Graphs in Secondary Schools, and Changes in Curriculum in Mathematics in the Secondary Schools

In addition, a joint session of the delegates to the Summer Institute of Mathematics and the Sixth Summer School of Mathematics was held on Saturday May 25, 1963, at Hans Raj College, in which the participants to the Institute presented the existing syllabi in mathematics in higher secondary schools in their respective states

Book Reviews

Reviews of the following books of the 'New Mathematics Library' series were presented by participants:

1. Numbers : Rational and Irrational.
2. The Lore of Large Numbers
3. An Introduction to Inequalities
4. Geometric Inequalities
5. Uses of Infinity
6. Geometric Transformations
7. Graphs and their uses

The presentations evoked great interest and led to useful discussions.

Recreational Mathematics

Shri D. R Kaprekar of Devlali talked on 'Demlo Numbers' 'Magic Squares' and 'Arithmetical Puzzles'.

Film Shows

The following films were exhibited through the courtesy of the United States Information Service:

1. Velocity of Light
2. Photons
3. Frame of Reference
4. Coulomb's Law
5. Straight Line Kinematics
6. Vectors
7. Simple waves

Reading Materials

BOOKS

The following School Mathematics Study Group books from U.S.A. were supplied to each participant along with commentaries for teachers. The lectures on algebra and geometry were mostly based on the S.M.S.G. books

Introduction to Algebra—Volumes I to IV

Geometry with Coordinates—Volumes I to III

Seven sets of New Mathematics Library series consisting of the following ten books each were also distributed among the participants:

1. *Numbers: Rational and Irrational* by Ivan Niven
2. *What is Calculus About?* by W. W. Sawyer
3. *Introduction to Inequalities* by E. Beckenbach and R. Bellman
4. Geometric Inequalities by N. D. Kazarinoff
5. *The Contest Problem Book: Problems from the Annual High School Contests of the Mathematical Association of America*, compiled and with solutions by Charles T. Salkind.
6. *The Lore of Large Numbers* by P. J. Davis
7. *Laws of Infinity* by Leo Zippin
8. *Geometric Transformations* by I. M. Yaglom, translated from the Russian by Allen Shields
9. *Continued Fractions* by C. D. Olds
10. *Graphs and Their Uses* by Oystein Ore

CYCLOSTYLED LECTURE NOTES

The following notes were cyclostyled and distributed to the participants to supplement the classroom lectures

1. *Revolution in Mathematics* by Prof. M. H. Stone.
2. *Art and Mathematics* by Nathan Altshuller-Court.
3. *Basic Concepts of Set Theory*—by Dr. M. K. Singal.
4. *An Introduction to Real Functions* by Dr. E. Starke.
5. *Collection of Data* by Shri D. B. Gupta.
6. *Probability* by Dr. E. Starke.

7 *Thoughts about Mathematics*
collected by Dr J N Kapur

8. *Matrices* by Dr M K Singal

9 *George Boole*

10 *Extract from the Report of the IX Annual Mathematics Institute*, Rutgers, U S A , held in 1961

11 *Extracts from the Report of the X Annual Mathematics Institute*, Rutgers, U S.A., held in 1962

Library

A small library of about hundred books on modern mathematics was set up for the use of the participants Arrangements were also made to enable them to borrow books from the Ramjas College library

Social Activities

A number of social activities were arranged The participants made a two-day excursion to Agra, Fatehpur Sikri, Mathura and Brindaban, where they visited the important historical buildings and famous temples. They also went on a sight-seeing tour of Delhi and visited all the important places of interest. An excursion to Bhakra-Nangal Dam, Rashtrapati Bhawan and Moghul Gardens were also arranged.

Suggestions for further Institutes in Mathematics.

1. The duration should be from four to six weeks
2 The selection of delegates should be made at least six months in advance and they should be provided with some reading material beforehand
3 Demonstration classes should form an integral part of the activities of the Institute.
4. The books listed in the bibliography prepared by a committee of the present institute should be available in all secondary school libraries.
5 The new mathematics may be introduced in some selected schools freed from a central examination
6. The reports of the proceedings of the various Summer Institutes in the U S A. be examined before finalising plans for the Summer Institutes of 1964.

7. A complete set of S.M.S.G books and other literature prepared in the United States should be made available to the organisers of the Summer Institute

B EVALUATION

By Members of the Coordinating Committee

The Mathematics Institute held at Ramjas College, Delhi, presented with enthusiasm the new mathematics that has been developed by the Secondary Mathematics Study Group (SMSG). Each of the participants was furnished a complete set of the *Introduction to Algebra* materials and of the *Geometry with Coordinates* materials. The *Introduction to Algebra* set included four volumes of text and four volumes of commentary. Several of the faculty and of the participants indicated that they wished that they had also been furnished the set on *Intermediate Mathematics*, which set includes two volumes of texts and two volumes of commentary. They wished to pursue the new algebra further than was possible in the texts supplied. It is recommended that another time the set of Intermediate Mathematics be furnished also.

Several sets of the *New Mathematical Library* were furnished as resource materials. These were used by the participants in seminars and later kept as a part of their reference library. This set included the following eight volumes: *Numbers Rational and Irrational* by I. Niven, *What is Calculus About?* by W. W. Sawyer; *An Introduction to Inequalities* by E. Beckenbach and R. Bellman, *Geometric Inequalities* by N. D. Kazarinoff, *The Contest Problem Book* by C. G. Salken; *The Lore of Large Numbers* by P. J. Davis; *Uses of Infinity* by L. Zippan, and *Geometric Transformations* by Yaglom-Shields. There was also available a set of seven volumes of *Studies in Mathematics*. There were no mathematics films as such as a part of programme but several of the mathematics-related physics films were shown.

During the first week, the Institute met both morning and afternoon, but as the summer became hotter the programme was changed. The schedule was from 8·30 to 12:30 each day, with periodic seminars held during the afternoon or evening. Unlike the Institutes in Physics, Chemistry and Biology, it is not necessary that the Mathematics institute be held in a University, for no particular laboratory facilities are essential. It would be better to hold a shorter Institute in a hill station, where the participants could work for more periods each day, and so have an opportunity to work more efficiently. It is recommended that in the future the Mathematics Institutes be held in hill stations where the heat is not so oppressive

Certain of the participants expressed the view that in future seminars it would be helpful to have a mathematics educator associated with the Institute who is quite familiar with the secondary school mathematics programmes in the schools in order to give additional help in showing how the new mathematics may be introduced into the school programmes.

The worth of this Institute was well summed up by one of the participants who has written that she valued most the knowledge gained through the lectures on set theory, cartesian products, matrices, probability, modern geometry and statistics, "for these lectures have urged me to rethink the basic concepts of the abstract nature of mathematics. It will at the same time enable me to prepare the college, bound students of the higher secondary school classes to continue their higher studies in mathematics in a better way than they did previously The link between the high school syllabi and the university syllabi is more clearly understood It is imperative that the missing links at all levels be forged, the missing links between the university and the high school, the high school and the middle school and the middle school and the primary school It has stimulated me to continue the deeper study of mathematics on my own apart from the teaching work in the classroom "

By Dr Emory P Starke, Visiting American Scientist

Traditional Mathematics Instruction

There are two major respects in which the traditional patterns of secondary school instruction fail to give our students an adequate understanding of the nature, scope, and accomplishments of mathematics

1. The subject is taught as though nothing of significance had occurred in mathematics during the last 50 or 100 years. But, on the contrary, vital new mathematics is being developed at an explosive rate (comparable to developments in physics and other sciences) and secondary schools must find ways of bringing their students farther along, so that these developments can be studied in college. Funda-

mental new content has been established and older concepts have been reorganized and extended, and the modern view is that the major emphasis of mathematics is concerned with abstract patterns of thought.

2 The subject is taught as though it consisted mainly of a series of stereotyped problems with solutions handed down by the teacher in textbook to be memorized by the student and reproduced upon demand On the contrary, the major emphasis should be placed upon developing a real understanding of the foundations of, and the logical relationships within mathematics The main purpose of problems should be to test whether the student has sufficient grasp of basic concepts and relations to be able to work out his own applications and solutions Seldom should the teacher tell the student what to think and what to do, but should rather present experiences through which the student can discover for himself the significant relationships and methods.

A Modern Approach

For the 34 teachers who attended, the Mathematics Institute provided a comprehensive introduction to elementary algebra and geometry, following a modern approach Texts and commentaries prepared by the SMSG were used as the basis for study.

While most of the teachers have posts at the upper secondary level, this basic work is necessary if they are to be able to give a competent, modern treatment of further subjects such as intermediate algebra and trigonometry

It is taken as a truism that no teacher should teach any topic which is too close to the boundary of his own competence He should know a considerable amount beyond the topic under discussion, in order at least to discriminate between essential and less important implications and to be able to answer questions which the brighter students may well ask

With this in mind, additional lectures were given on such topics as: The Nature of Mathematics, Introductory Set Theory, Probability and Statistics, Vector Algebra and Linear Spaces, Matrices, Boolean Algebra, Theory of Numbers, Continuous Functions. In each case the subject-matter impinges upon and illuminates the material of secondary mathematics No lectures were given on topics too remote from the secondary curriculum.

Occasionally a lecturer fell back into old habits and adopted a "This is it, I am telling you" attitude. But in most cases the approach was to lead the listener to experience the pleasure of discovering the desired conclusion by himself. On the whole the Institute was beautifully organized and the lectures caught the spirit of the modern approach.

The reaction of the participants has been highly gratifying. They are enthusiastic about the new approach and have caught much of its spirit When they return home, even with the same old curriculum and examination system, it will not be possible for them to fall back into the old ways of teaching Much of the spirit and some of the materials met this summer will surely find their way into the classroom work this fall After all, this is the only real test of the success of the Institute.

On the whole, I would give this Mathematics Institute a very high rating. It has been an admirable start in a movement that can only go forward in outreach and effectiveness.

With experience gained this summer, there is a point at which some improvement might be made for summer of 1964.

In some way the new approach and new emphasis must be made clear and vital, as also the differences in content between the new and the old treatments The topics where the differences are slight need little attention This will require a very discriminating lecturer, thoroughly familiar with SMSG materials and capable of leading a vital, exciting discussion. (This is also the most difficult feature to organize satisfactorily in American institutes)

By Participants

All the 34 participants in the Mathematics Institute responded to the questionnaire. Responses to four of the questions are summarized below:

I. In view of the purpose of the summer seminar to upgrade secondary school science education, which experiences in your summer seminar do you value most? Why?

The Approach and New Content

a) The new knowledge of "Set Theory" in SMSG books—16, Number systems—11; Modern Geometry—11; Matrices—8; Study of polynomials and their graphic representation side by side—6; Statistics—3, Probability—3

b) A new study of Number theory, Set theory, non Euclidean geometry will make mathematics more meaningful and be of great interest to students—1

c) Representation of Trigonometry by unit circle, new and simple—2

d) "Set theory" very convincing. Help in teaching algebra and geometry as correlated subjects and so save time—3

e) Boolean algebra was new to me—7

f) Treatment of algebra gave increased grasp of subject—1

g) Modern methods of teaching algebra and geometry—3

h) Importance of abstraction and generalization in the study of mathematics—7

(1) It is more abstract and far better than traditional methods—2

(2) The introduction of the subject of mathematics with abstract background very important—1

(3) Better results forthcoming for university bound student from abstract approach—2

(4) Abstract starting point, rather than concrete better for selected student group—1

i) More stress on basic structure of group, ring, number systems, not on merely solving problems—4

j) New approaches avoid mechanical calculation; avoid merely drilling and computing—4

k) Rather than drill on standard results, I like idea of helping young students grasp fundamental concepts—1

l) Students will understand old problems in a new way—1

m) Original approaches pave way to original thinking; deviate from traditional way of teaching—pave way for originality and research—2

n) Delete mechanical aspects. Study the underlying mathematics principles—2; Minimize computational aspects; logical thinking will result—2

o) A better view of modern mathematics—4
p) Mathematics is an interesting subject; it is not merely solving problems—2
q) Rigor is an essential part of mathematics; rigorous methods of proof demanded—4
r) New experience in seeing differences between Euclidean and non-Euclidean geometry—1
s) New approaches will clear confusions in students, who now accept conflicting ideas—1
t) Some of SMSG treatment relieves students of unnecessary cramming—3
u) If SMSG material were introduced, students would have better grasp—1
v) Will help students build a strong foundation for higher mathematics—1
w) History of mathematics is fascinating—1
x) Ideas on history of mathematics can be easily introduced—1

Teacher Growths

a) Strengthened view that present syllabus in mathematics needs revision—2
b) Syllabus must be revised from primary grades on up—1
c) School mathematics must be unified—1
d) There should be a link among teachings of mathematics in high school, higher secondary school, and college levels—5
e) There must be a greater emphasis on the growth of correct mathematical ideas from grade to grade—5
f) Have had to rethink my own concepts and can now better help college-bound students—1
g) Mathematics content must now be selected very carefully; content must be graded—3
h) The upgrading of high and higher secondary school mathematics implies there should be an upgrading of knowledge of the teacher—1
i) Practical ways found to present algebra with new approaches—9
j) Present syllabus in geometry must be modified—11
    (1) There should be introduction of space geometry—3
    (2) Fusion of algebra and geometry by different coordinate systems needed—1

(3) Geometry showed new treatment, yet simplified—3
(4) In geometry, we can be more honest and sincere—1
k) The present examination system must be changed—6
l) Appreciated stimulating exposition by experts—4

Films

a) Film on vectors very interesting and useful—15
b) Films quite interesting, although more on physics than mathematics, except vectors and relativity—9
c) Film on relativity much enjoyed—3
d) Seven films shown, three related to mathematics, rest to physics, but all interested me greatly, they made the subject more comprehensive—3
e) We need more films on mathematics—2
f) Films shown were beautifully produced—1

Discussions

a) Exchange of views about problems of teaching present syllabus valuable—2
b) Discussion with those from other states important—1
c) Group discussion of mathematics teaching problems valuable—2

II. Using the present syllabus, can you see ways to introduce new content and new approaches in your classes? To what extent can you do this? Give an example.

Changes Possible in Teaching of Algebra

a) "Set theory" can be easily introduced and present topics in algebra explained on this basis—16
b) Teaching about number fields very important, early—7
c) Algebra easy to incorporate, a fascinating approach—7
d) Theory of inequalities important—7
e) Teach algebraic equations and graphic representations side by side—5
f) In algebra, commutative and distributive laws will make ideas of multiplication and factorization simpler—3
g) Use new symbolism in present syllabus—1
h) Shift emphasis from mechanical calculation to insight and understanding of basic concepts—1

i) Our present syllabus is quite vivid and wide and we can use much of new approach—1

j) Equivalence relationships will remove most of the mistakes which students make in problem solving—1

k) New concepts like those of "Set Theory" number fields, algebraic structure could be added on without impairing the preparedness of the student to write the H S Examination—1

Example

Isomorphism between line and number systems, the extension of the numbers, from natural numbers to complex numbers, could be a prelude and a background to a study of the theory of quadratic equation The theory of equivalent sentences and the 'revertible' steps taken to obtain them could be a foundation for the solving or equations. The concept of 'domain' of a variable X, in solving equation must be included too. Exclusion of the concept of 'domain' creates a lot of confusion in the traditional approach. Also the metaphysics of 2 and—1 could be explained.

Changes Possible in Teaching of Geometry and Trigonometry

a) No change possible with present syllabus, except some emphasis on nature of the approach, that is, in building an awareness of other geometries—6

b) With coordinates, not possible now in higher secondary curriculum as there will be a language difficulty (Some participants found this true for themselves)—7

c) Combine geometry and coordinate geometry, as these can be usefully integrated—6

d) Make students aware of space geometry; do not confine them to plane geometry—2

e) I hope that I will enrich my students with the new approaches made in SMSG books such as that of linking the studies of geometry and coordinate geometry, proving the Pathagorean theorem, in dealing with inequalities and functions graphically, and establishing some trigonometrical formulae, as SIN $(a \pm b)$ with new approaches—1

f) Trigonometry books should inspire us to adopt new approaches—2 nts

syllabus too fixed to allow changes—2

syllabus must be enriched with new materials before
n use them—2

syllabus and examination must be changed to teach
aterial—2

t syllabus must be reoriented to best utilize summer
ences—9

syllabus allows no new content, but we can use such
pproaches as "truth set of open sentences"—1

seminars put cart before the horse; might we better
e the syllabus and then have the seminars?—1

r system must be taught early in arithmetic—1

y of mathematics and life of mathematicians can be in
ced in present syllabus—4

syllabus remains the same, much good can be done—2

f the contents and much of the spirit of modern mathe-
s can be incorporated—1

elieve in the approach to learning you experiences in
minar, how do you plan to help others to become aware

form a Mathematics Club of teachers in which month-
etings are held to study the new mathematics—15

try to convince my fellow teachers and principal on the
pproaches—9

circles of modern topics must be conducted—4

try to get DPI's and State Education officers to organize
ir seminars at district levels—3

a mathematics club for students—4

circulate literature to mathematics masters of the state
ifuse them with the utility of the new approach by asso-
n and by the management of seminar meetings at the
of every month—1

organize the mathematics teachers of our 25 interme-
and degree colleges—1

journal or organ where experts can write articles about
ew mathematics—3

cyclostyle the mathematics lectures for my brother
ers—1

j) Try to place SMSG books in my school library—1
k) I can give help to others in organizing similar seminars at state level—5
l) Write articles and circulate them through various educational journals—2
m) Help some schools undertake a project in teaching the new mathematics—1
n) Each state needs one model school to experiment in the new approaches and record its successes—1
o) Have extension service departments in each teacher's college call a meeting and have delegates present new materials—2
p) I can teach one experimental group of students—1
q) Start a small library with books and publications on recent developments—1

IV. State some practical suggestions for improving Summer Science Mathematics Seminars in the years ahead.

Suggestions relating to Programme and Staff

a) Participants should be informed of their selection two months ahead—12
b) A planned programme should be chalked out and distributed among the delegates before the start of the seminar so that delegates may come prepared—20
c) Books for the seminar such as SMSG should be sent to delegates early, possibly one to two months ahead In this way such books would not have to be gone over in seminars but could become base for discussion groups—12
d) Books should be translated into regional languages against Indian background and circumstances—5
e) SMSG books should be in every secondary school library—6
f) A comparative study of mathematics syllabi in several countries, such as Japan, U.K, U.S.S.R, U.S.A should be made—2
g) Need more books on new programmes—6
h) Need guided discussions on present syllabi with practical suggestions for meeting difficulties in presenting new materials—11
i) Committees with homogeneous interests should be formed early in seminar and planned discussions held—4

j) Include calculus, dynamics, hydrostatics and other applied mathematics—1

k) Equal emphasis should be given to method as well as content—9

l) Group at seminars apt to include teachers at high school, higher secondary, and intermediate college levels, so their special abilities and needs should be considered—1

staff, as well as members from the university mathematics faculty—9

m) Lecturers from teacher training colleges should be part of the

n) Demonstration lessons at the seminar using the new approaches will be helpful—7

o) Some members of the seminar faculty should be housed in the hostel with participants. This would create basis for friendly informal discussions—5

Suggestions relating to Time and Living Accommodations

a) Time for the seminar in mathematics could be shortened to four to five weeks by working more hours per day, having study materials early, etc.—20

b) Hold seminars of short duration during Christmas holidays, Puja, or Dussehra—1

c) Medical help should be provided free—9

d) Institutes should be held six days a week and close earlier to allow for opening of northern States' schools—3

e) Institutes should be held in hill or resort stations for vigorous work—12

f) More teachers can attend and the new programme will be spread if institutes are held on an area or state basis, not an all-India one—14

General Considerations

a) The same delegates should be utilized in some way in future institutes—2

b) Secondary school students should attend the Institutes to verify validity of material presented—3

c) Invite to the Institutes teachers who are trying experiments in mathematics teaching—1

d) All participants should be made to take an active part; to read papers before the group, to take modern tests, cover assignments, and do library research—8

e) District Education Officers should be invited to the Institutes so they can follow up work in the state—1

f) An active association of all participants should be formed to supply new materials and to help teachers with difficulties in trying out new programmes—2

PART THREE

CONFERENCE OF EDUCATION SECRETARIES

13

INAUGURAL ADDRESS AT CONFERENCE OF EDUCATION SECRETARIES

P. N. Kirpal*

We have been engaged during the last two days in evaluating the progress of educational development in the Third Five Year Plan and have been wrestling with various problems as best as we could. The problems will continue with us; that is inherent in the nature of human affairs; but there is one problem which will not abide—science education. In every way it is so urgent and of such overriding importance that unless we, who are charged in different ways with guiding educational policies, start tackling it in earnest, we would be setting back the pace of the nation's progress by a generation Whether we consider the needs of industrial and agricultural development or raising the economic viability of our people or building up the defensive strength of the country or, in a wider and even more significant context, the social progress of the nation and the social attitudes essential for such progress—science lies at the base of them all.

We therefore thought that it would be appropriate to set apart a whole forenoon from our conference to discuss science education and adopt an approach somewhat different from the one through which we have examined our other problems.

In our two-day discussions we referred frequently to quality in education. That is the very core of the problem of science education —quality or the pursuit of excellence. Science education is either quality or nothing Here, there is no half-way house. Even the paucity of our resources will not justify teaching of science which may be out of date or teaching it in a way which leaves with the pupils a permanent distaste for the subject.

In the Third Five Year Plan great stress is laid on expanding at every level the available facilities for science education. This is, of course, imperative; but expansion alone will not take us to the goal we have set for ourselves, if expansion means merely multiplying the existing defects and deficiencies, projecting them on a larger screen and on a bigger scale. This session of the Conference is therefore to consider the other dimension of qualitative improvement in science education. We are particularly fortunate to have with us for this session eminent experts from the U S A and from our own universities, who have given a great deal of thought to this matter

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In considering complex problems such as the present one, it is exceedingly hazardous, but nonetheless tempting, to reduce them to some simple prescriptions If I were to do this for the problem of science education, I should like to suggest two factors—the curriculum and the teacher—the word curriculum being used in a comprehensive sense—the body of knowledge, skills and attitudes which are to be taught and learnt and the goals and the means for such teaching and learning.

In the teaching of science, curriculum improvement in this broader sense is fundamental to any organized effort at improving the quality of science education. The distinguishing feature of science lies in its almost unbelievably dynamic character. It is estimated that its body of knowledge is doubling itself every ten years More fundamental changes in scientific concepts have taken place during the last three hundred years than in the entire history of mankind, and more changes have occurred during the last fifty years than even during the last three hundred years. This has two-fold effect on the curricular problems of science education First, to teach a science which may be out of date and no longer valid is almost as bad as not teaching science at all. Therefore, a close examination of our syllabi, textbooks, and teaching aids and methods becomes essential Secondly, the sheer pressure of a larger body of knowledge makes it necessary that the first introduction to it, selectively and in an appropriate form, should be given at the secondary stage otherwise the universities would be compelled to do the work that the secondary schools should be doing, in addition to undoing what the secondary schools may have done, thus diverting themselves from their legitimate work of leading the students to search at a deeper level in their field of study

It has, however, to be borne in mind that however well a curriculum or a textbook may be prepared, they will be unavailing if the teacher is not ready to make use of them and does not understand the purposes they are designed to serve The training or retraining of teachers is therefore one of the major tasks. Such training should, however, be focussed on curriculum improvement, one leading on to and reinforcing the other Neither is sufficient in itself They must be considered part of the same integrated process,

NCERT Exhibits of Science Literature at Education Secretaries' Conference

The Annual Combined Book Exhibition of U. S. A. Science Books at the Education Secretaries' Conference

Demonstrating of PSSC equipment at the Education Secretaries' Conference

These two are the main themes for this session of the conference.

We can study with profit, bearing of course, in mind our own conditions and needs, the experiences of other countries where, in very recent years, a tremendous revolution in the teaching of science at the secondary stage is under way. In the U S A. eminent scientists and specialists have been working together with secondary school teachers to prepare new curriculum materials and textbooks You will see some of these materials on display here. What is of particular importance is the way these materials in physics, chemistry, biology and mathematics are being prepared For example, the textbook in physics—which incidentally has been reprinted in an inexpensive Indian edition by the National Council of Educational Research and Training in collaboration with the United States Information Service—is the result of the labour of eminent physicists and secondary school teachers Along with the textbook, there is a Laboratory Guide, and a four volume Teachers' Resource and Guide Book. After careful experimentation, a set of laboratory apparatus has been designed and produced for use in carrying out over 300 experiments in the textbook and more The whole set of apparatus costs the equivalent of Rs. 2,500 only. If we had such inexpensive apparatus with high instructional value evolved here, it would not only mean better science teaching but also covering, with the resources we have, at least five times the number of schools that we can with our existing type of apparatus. Thus, there is a series of fifty-four short films which supplement the demonstrations and laboratory work. A series of books on different topics in physics has been published—twenty four so far—which provide stimulating supplementary reading material for the student. Secondary school teachers are being introduced to all these materials through summer institutes and similar training courses. Outstanding as the programme is, its most distinctive feature certainly is the close collaboration between the universities and the secondary school system.

We have made a beginning in recent months and those who have been closely associated with our programme are present with us in this session The programme was jointly sponsored by the University Grants Commission, the National Council of Educational Research and Training and the United States Agency for International Development, and took the form of six summer institutes, which were attended by secondary school teachers nominated by the State Departments of Education—one for biology in the University of Madras, chemistry at the University of Poona, mathematics at Udaipur, physics in the University of Delhi, and two summer institutes for general science, one at Dehra Dun and other at Hyderabad In these summer institutes, the secondary school teachers have been provided with an opportunity to learn from experts eminent in their fields about recent advances in their subjects and this knowledge would also be incorporated in school curriculum The National Council of Educational Research and Training has prepared an experimental syllabus for general science for elementary schools Panels of experts are also preparing textbooks for secondary schools in physics, biology, chemistry and mathematics. The programme that has just begun is proposed to be expanded in the coming years. Next year we are hoping to have sixteen summer Institutes and the year after next sixty-four They will not place any direct burden on your budgets, which have already a heavy load to carry We hope that the State Departments will take the fullest advantage of the opportunities we are trying to organize

Before concluding and calling upon experts to present to you their experiences, I should like to express our deep appreciation of the help and cooperation received in this programme from U S A I.D. and the schools from U S A who came over at short notice and have worked through the summer months in these summer institutes, to the University Grants Commission which has taken the main responsibility for organizing the programme, to the universities which placed their facilities at the disposal of the programme, our university professors who have given so unstintingly of their scholarship and guidance, and the National Council of Educational Research and Training I should like in particular to thank Dr. Bingham who has been with us from the very beginning when the idea of this programme first emerged.

14

THE DEVELOPMENT OF SCIENCE CURRICULA FOR SECONDARY SCHOOL STUDENTS

J. Arthur Campbell*

Importance of Cooperation between University and High School Specialists

In our own country, we have produced some materials which would have been impossible had it not been for the very close cooperation between expert university people and expert high school people, and the former's interest in high school problems. High school children in our country want to do better work than they are doing at present Most of them take science and go for higher learning to the universities. I am glad that you have a group for revising your curriculum and that you have university men as members of this group, for I think such a group is essential if real progress is to be made

A curriculum should be grafted to the soil

Whenever one country exports its curriculum, it does it in connection with its own problems Exporting a curriculum is very similar to exporting a plant. Some kinds flourish by hybridizing and some will not grow except in their country of origin So I really do not know if the materials perfected in the United States will do well in other countries. There is a very great interest in them throughout the world and we are encouraged by a number of countries wanting to look at these materials and see how they could be adapted I think it is important to have a good look at them before adapting them.

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Science is what Scientists do

We say that science is what scientists do. In most high schools in the United States, the science teacher does not deal with science in the way in which scientists operate and very few scientists operate in the way in which the material is presented at the high school level. The object of these new materials is to try to put the high school student, even though he may be only 15 or 16 years, in the same general framework that a scientist would be at that level So I start with the fundamental—science is what scientists do It is not just an accumulation of facts, which must be committed to memory. It is an active, growing body of knowledge It is a method of approach to knowledge

New Programme need not be expensive

During the last five years, the United States Government spent about 30 million dollars on the high school programme. And this is a great sum of money. But we discourage many other countries from launching such a programme, for, we feel, it is not necessary for any country to spend anywhere near this sum. And the reason is—I say this with some conviction—that we have made many mistakes and some costly mistakes, that other people do not need to make, if they can explore and solve the problem in their country at a much lower cost

Use of talent in the New Programme

In addition to this very large amount of money spent, of much more important significance is the talent used in a new programme This is the first time in our country when really top flight scientists have participated in writing materials for the secondary schools. Fifty years ago, biology, chemistry, physics and mathematics books for the high school were written by top-flight scientists But during the last fifty years, this has not been true.

Joint Endeavour of University and School Specialists

The second major contribution, one without which none of these projects could have succeeded, was a close cooperation between the top-flight university people and top-flight secondary school people It is quite easy for university people to design a good science book which is completely inapplicable to the high school level So every single one of these studies has been a joint approach by an approximately equal number of high school teachers and university teachers.

In the CHEMS project, which is fairly typical, about 40 man-years of work have gone into writing the material Actually it is more than 40 men. it is about 300 men, very competent men who have spent a great deal of time to add up to 40 man-years.

The laboratory is an important place

As far as the fundamental assumptions behind these materials are concerned, although I am a chemist and am concerned with the chemical materials, I think it is safe to say that all these projects have worked in the same way. We made fundamental changes in the organization of the material and made provision for a rich use of the laboratory by the student to make the experiments himself Let me cite one example When student comes to the school on the first day of our chemistry course, he is given no books. He is given only a candle and he is asked to observe what he can about the candle and write it down. This is the first experiment on the first day On the second day, there is another experiment. Thus he does experiments during the first two weeks of school. He does not get the textbooks until the third day He does not get the laboratory manual till the second week. We no doubt think that these books are very good, that they are significant books, but the more important thing in science is the laboratory The laboratory is the scientist's fort. It is where scientists learn and it is where students have to learn by making experiments and not take it for granted that what the teacher says must be right and true On the other hand, when a student first goes into the laboratory without any idea as to whether what the teacher says is right or wrong, he has an open mind and he can do the experiment as a scientist. Scientists do not go into the laboratory only to prove that some one else is right or wrong It is also to explore and to discover While it is often true that the teacher knows what the student has discovered, it is not always true, and this can be very embarrassing to the teacher. One big change in the teacher must be that he must be willing to be embarrassed occasionally, to have the students discover things that he did not know, to have students ask questions to which he does not know the answers. This will happen in any real exploration of science.

So, we place emphasis on designed laboratory experiments, which are really experiments through which students explore and discover for themselves and then go to the class and discuss these discoveries, compare results, learn something about the nature of scientific experiments, and then, on the basis of these experiments, discover the major concepts of science.

Concepts more important than detailed knowledge

This I think is second major emphasis after the laboratory The only way for a scientist to discover and double his knowledge is to forget about detailed knowledge No one has a large enough brain to store all this information The only way for a science student to master this information is to organize it under general headings or concepts. Therefore, what will happen to the student in the laboratory is we hope, that he will make certain discoveries He will be able to generalize with these discoveries in terms of concepts He will be able to fit together his discoveries and also all other things which he will discover in the future.

This change from a descriptive approach to a conceptual approach is a very marked change. Previously in chemistry, physics and biology, students were taught a set of facts They were taught to collect certain data, to name certain chemicals, and to learn that when copper sulphate is mixed with sodium sulphide, you get copper sulphide. Now many students would have no idea what is going on unless they did the experiment with copper sulphate, sodium sulphide and copper sulphide Therefore, it is much important to do the experiments, and then fit them into some generalised schemes.

How these materials were written

We then wrote the materials very rapidly Our own study is now in the third year Materials in the first year were written in three weeks and then re-written so that the texts, laboratory manual and the teachers guide were prepared in six weeks Then these materials were tested in the schools by teachers and re-written several times. The fourth edition is now being printed.

How Good are these Materials?

The question is, how useful are these materials? It is easy enough to write materials and to think you have done a good job. How do you know they are useful? You may be interested in the typical reaction of the American teachers and students to these materials.

In the first two years of our study, I had not met a single high school teacher or a single college teacher who did not say that these materials could not be taught at the high school level, that they were much too difficult. I think the reason is that 50,000 American students were studying the material and in the examination some failed and some succeeded In the next examination, however, a few more succeeded. Therefore, when we look at the new materials, we should remember our own education, we did not learn all that we did until may be in the second year or even the third year of the university The material here is put in a manner and in a language which is accessible to the high school students, and in the most accessible context, namely the laboratory Formerly this material was put into the university course and now it is at the high school level, because we feel that the first course in science should give and discuss the major ideas of science They will be very useful and important to the student if he goes to the university and even more important to the student who does not go to the university. This material is not intended just to be used by university bound students. Many American students take science in the high schools and that is all the science they get, and it is extremely important for them to learn science properly and to get from science something which they can use later on, something which they can remember

Take, for instance, the question of the preparation of oxygen. It is important for the student to have this information. I know myself as a chemist that the standard answer to the question, 'How do you prepare oxygen,' is 'Heat potassium chlorate.' But no chemist really heats potassium chlorate to get the oxygen he wants. He gets it from out of a steel cylinder and it is important that the students should also know how this is done

The material prepared already is reasonably successful and we can convince many people of this fact We not only convinced the teachers, but groups of teachers meeting together behaved as in a religious meeting. They often say. 'My whole life has been changed. I will never go back to the old methods. The new material is much better,' and so on. They are enthusiastic and they have found it teachable

Good Schools, Good Teachers and Good Students

For the first three years we had groups of 6 to 12 teachers from four different geographical areas to try these materials They met once a week or once in two weeks, discussed their problems with the local university person and they let us know their reactions so that we could revise the materials In the first place, we took excellent teachers to work with, because we wanted the most favourable situation for the first experiment We, therefore, made sure that we got good teachers. Secondly, we selected good schools and lastly we had good students So in the first year, we had good teachers, good schools and good students. But last year we extended the trial to the average or the just below average teachers, schools and students We have to try the materials with them also, but at the beginning it is essential to have excellence for the try out

Evaluation

Finally I come to the question of testing We do not have state syllabuses and a national syllabus We do not have a national or state examination Therefore, it is easier for us to experiment In this experimentation, however, we have certain restrictions Students who go to universities are expected to know certain things There is the national examination called the College Board Examination in Chemistry, which has to be passed by the university-bound students. Our approach was, 'Forget about examinations' The students did not take that examination We recommended to the universities that these students had a different kind of course and that the usual examination would not do. Therefore, we set our own examination. We provided the universities with everything needed for this examination. For example, New York Universities have the regional examination which the high school student take if he wishes to go to the university. Our course does not prepare students for the regional examination. But their number was only 10 and therefore, we could have the new examination and on the basis of the new examination the students got qualified or not qualified.

Now why was a new examination needed? It was needed for two reasons. First, the established examination asks many questions which are not covered by the new materials Secondly, our materials cover many ideas that are not covered in the usual examinations Therefore, it is unfair to students to take an examination for which the course is not designed. Therefore, it is very essential to change the examination system, if one wishes to experiment, especially since our emphasis is on laboratory rather than on just proof and on the use of the concept rather than the descriptive

Our examinations are with open books The students are not only allowed to make use of their books, but they must use their textbooks because in certain questions we say Turn to page so and so and give us such and such information. You may wonder that if students are allowed the use of their textbooks, there will be very few failures in the examination But even if we say, 'Turn to page

173 of the textbook and answer the question,' the student must be intelligent and have some information to synthesise his answer rather than just repeat.

Finally the results of studies in respect of chemistry, biology, mathematics and physics programmes are given out in the form of newsletters which are available on request.

SUMMARY OF DISCUSSIONS

(A lively discussion followed Dr. Campbell's address. We summarize below the questions raised and the answers given)

Q. How do you propose to keep the new material that has been developed for the chemistry programme up to date, particularly in view of the rapid advance in science in the modern age?

Ans. We feel that this type of material will not get out of date quite so rapidly, for fundamental ideas in science do not change as rapidly as their applications So for at least three years we will not probably require a major revision. But at the end of three years we would look into the material again and if revision is found necessary, it will be carried out. I might also point out that it was not really the function of this group of specialists to publish books We hope that when this experiment is successful, other authors will come forward to write books and other publishers will come forward to publish them in the usual commercial way. The primary aim of this group was to provide a new kind of material and not to get new books published, in other words, this was an experiment in science education.

Q. Can this material be translated into our Indian languages for use in our schools?

Ans The teachers in Poona were of the opinion that this material could be taught successfully to Indian students. A direct translation could be arranged as this group owns the copyright and it will be open to anyone who wishes to translate it.

Q. When considering changes in curriculum, the most important factor is the reaction of the old type of teachers to the change. The problem is one of converting the teacher used to old methods to the new ones.

Ans The teacher's response is the key to the whole problem. In the CHEM-Study programme during the first year, the teacher was not really saying that the student could not understand this material. What he was really saying was 'I do not think I can teach this to my students.' The teachers did not say 'I won't look at this material, I won't have anything to do with it' Every teacher said that the materials were good, but all were not sure that they could teach them But later they said 'I would like to try them; they look interesting.' Then they did try them and they found they liked them a great deal better So I think the initial answer to this question is that one must first select the teachers so that there is good teacher response One must try the experiment with excellent teachers. The worst mistake that any administrator can make is to say to the teacher 'Next year you will teach this course' Every teacher likes to be a good teacher If he finds that this material works well in one school, others will take it up in their own schools

The solution of the point raised, therefore, is to pick the good teachers in the first instance, in other words, those who will offer minimum resistance. Speaking for ourselves, in the first year we had 24 teachers in the whole of the United States. Next year we had 120 teachers and in the following year we had 700 teachers. Next year we shall have about 2,000 teachers

Q Is the book on '*Physics*' a self-contained textbook in any school or in a set of schools in America? Do you teach all that is contained in this book and nothing else apart from the usual ancillary material? I find that quite a good bit of physics, both experimental and theoretical, which was taught in the old age, has been deliberately omitted. Especially have I noticed that the topic on sound which in our student days, we considered quite interesting and instructive, is not here Is this a part of the new approach for the teaching of physics, to drop out a good bit of such material and concentrate only on the fundamentals and experimental materials needed to illustrate the fundamentals?

When the students proceed to the universities and take up original work do they feel the omission of such material in their earlier education? Do they have to go to the older type of textbooks in order to fill this gap in their knowledge? As a result of these textbooks are you producing students, who after graduation are fully equipped with the concepts and knowledge which they are expected to have at that level?

Ans. These omissions are deliberate Let me give you the reasons for this omission. There is a common saying used in the United States 'A good teacher is known not by what he teaches, but by what he does not teach?' He should not cover the entire syllabus. He should teach certain basic things and leave somethings for the students to apply them Large areas have been omitted in order to make students spend sufficient time on the areas not included. There is almost nothing in the PSSC book which the student can use for an examination He is given only some fundamentals and he is then expected to apply these fundamentals to other areas. People may differ widely as to whether the right things have been omitted Many people feel that sound should have been included. Many others feel that nuclear ideas should have been there Whatever the view, the omissions are deliberate, even if ill-chosen.

As for the student who goes to the university, he does not feel any gap at all, because in the first year of university he will cover ideas of sound, Ohm's law, nuclear ideas etc, which he had not learnt in high school classes. The one who does not go to the university will always have this gap. Therefore, what one tries to do is to select those ideas which are most important for terminal students.

Q Is this a complete textbook in some schools?

Ans It is a self contained text in the sense that it is the only book that is used Not many schools get through the whole book. They have to be selective. They do only 250 to 300 minutes a week for about 35 weeks. At the rate of 5 hours a week, they have about 160 to 170 hours to cover the whole material Some good students generally supplement this by selected material, but for most of the students, it is a self-contained textbook

Q Could you give us some idea of the organization of science studies in American schools? Do you start with the synthetic approach of general science and then at some stage branch off the students to the various specialisations, botany, chemistry, etc? or is the synthetic approach maintained all through even when there is specialization?

Ans. The system varies greatly from state to state and from school to school On an average, students get some contact with science up to the 7th or 8th grade To begin with they study natural phenomena in the early classes and in the 7th and 8th grade, they come into contact with general science and most of them are taught through descriptive courses. The first time a student runs into a specialized course in a particular branch of science is usually at the 10th grade level at the high school Usually he takes biology in the 10th grade, chemistry in the 11th and physics in the 12th. They are all one year courses Many students take a second year of biology in the 12th grade so that a biology student has two years of biology and one year of physics and one year of chemistry.

Q. There are many countries where physics, chemistry and biology are taught as three-year courses. India is one of them Would you please comment on this?

Ans The same problem exists in most European countries. The study of science is extended over many years as opposed to one year We have been considering it for several years I know of no American scientist who thinks he must have a year of physics, of chemistry and of biology Even if the same teacher teaches physics and chemistry, he forgets what he has taught in chemistry when he comes to the physics class. There is very little tie between these two. My own feeling is that there is no particular advantage of one pattern over the other If the period is too long, the student forgets what he has learnt earlier. When it is for one year, many students at least retain something after forgetting others

There is one other point which determines this issue in the universities. We have a very fluid population. If we extend a course over three years, it would be difficult for the students because of this great mobility. In a more stable society the three-year system would not present this difficulty In other words, the one-year system is the only one that can articulate reasonably well with our universities.

Q You referred to the supreme importance of laboratory work. Laboratories are an expensive item to be established in a poor country like India. We have about 20,000 secondary schools, which we want to turn into science schools. The need for laboratory is very great In the American International School for example, the classroom is used as laboratory. It is so built and so equipped that the teacher teaches in the classroom and uses the cupboard etc., as a sort of laboratory. Are there any experiments being conducted on this subject?

Ans In many schools in America enough laboratory facilities are not available and they even use toilet as a laboratory. In the New York City schools, for example, this presents a tremendous problem. Students are allowed a very short time, say, 40 minutes to do their experiments In some cases they go into groups The equipment is kept as simple and cheap as possible. Where the situation gets really very difficult, two or three students can go to the teacher's desk and do the experiments in front of him This is not very good, but it is better than nothing

(In this context, the Director, Summer Institute in Biology in Madras, reported on certain calculations which he had made relating to this subject. He said that the set of 75 experiments included in the yellow version cost about Rs. 1,400 including chemicals and glassware. The yellow version would take about 3 years to be completed and its cost would therefore come to about Rs 400 a year or roughly a rupee a day Some of the expensive equipment like microscopes, frigidaire, hot oven etc., would cost Rs 5,000 to Rs. 10,000 All the experiments could be performed with improvised apparatus)

In American high schools, the cost of the chemistry course comes to about 200 to 300 dollars for a school of about 30 students

At this point I would invite the attention of the group to the possibilities of motion pictures in the teaching of the science curriculum Each of the groups had produced motion pictures which were designed to be used at a particular point of the course rather than on some day when the students do not have anything else to do.

Although they are expensive, they allow students to see experiments which they cannot possibly see otherwise and to acquire ideas which it would be very difficult to offer in any other manner If in any of your schools you wish to try some of these materials they will be available on free loan or at least at a very low cost.

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HIGH SCHOOL CHEMISTRY SHOULD BE MODERN CHEMISTRY

H . ARNIKAR*

The main problem is one that is realised by all concerned, namely, that standards in our country as compared with other countries of the world are extremely low. It is this realisation that has motivated the organization of seminars as one of the efforts to overcome the low standards.

Chemistry is what chemists do. What we do in the laboratory is not what we are taught by somebody else. The main emphasis of the new approach is that the boy should do the experiment himself. He draws his own conclusion. In the Poona seminar we were inclined to follow the old method during the first few days. One of my colleagues would describe a particular experiment and then the participant would go into the laboratory to do it. He was to record the results. This was a classical way by which we had learnt.

Then we tried a different method. We did not give any instructions as to what should be done, except to pose the general problem. For example, here is a candle. You know its composition. Find out the heat of combustion. Or, here is an acid or here is a base. Neutralize them. Find out how much heat is provided and so on. When they had conducted the experiments, the results were tabulated and revealed extraordinary conclusions. Certain characteristic errors were made. The study revealed very significant reasons as to why these errors occurred. The new method of experiment is comparably superior to the old classical method.

But the major question still remains. The majority of the participants are frustrated. They say, "We have learnt so much here. What will we do when we go back? We will be a drop of water in the ocean. We will not be allowed to teach these things? The syllabi are rigid. We will have to change them."

Since we are all agreed upon the main object from which there is no deviation, the only question to which we should apply ourselves is what shall we do in the immediate future and how shall we proceed about it Shall we upgrade all standards in general? The teaching of science or for that matter any subject cannot be widely different from one problem to another There is no reason why syllabi should vary widely from state to state There can be a central body to formulate syllabi, taking into consideration all the factors and then to enforce such a syllabi in all the states In my view this is one essential thing that must be done.

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Secondly, there is a process of weeding out. In the opinion of most of us what is important is the approach to science—it is the method and not the content that is important. Once we train the mind along with scientific lines—performing experiments, observing, drawing conclusions, advancing the theory, testing its corrections by further experiments, it is immaterial what particular experiments are conducted and what specific content areas are covered It is not possible to have everything that science has been giving from the beginning of its development We have to weed out much that is less important so that time and room may be found to incorporate modern concepts. As a chemistry teacher myself I cannot remember all the 92 elements and all proportions and properties and combinations. It is a useless load on the mind. So it is essential to weed out of the course a judicious and large number of less important things. For example, in these new chemistry materials you will find that the treatment is totally different even from the first page and you get introduced into electronic concepts and periodic classifications and so on, early.

These are the ideas which the Indian boy misses in the present set up So it is imperative to change the syllabi I may mention that the Maharashtra Secondary School Board has a very progressive and favourable approach towards this matter We had a lengthy discussion with the Chairman of the Board and they are seriously considering how to bring about some change. Let us, therefore, apply ourselves in a concrete way to work out what we shall do, how we shall do it and what is immediate; that is, what must be done at the moment.

Second in importance only to the revision of syllabi is to modify the method of examination. In our method we usually have a short question paper of 3 hours duration and the students give an answer paper of 30 pages. In the new method on the contrary, the question paper is about 10 to 12 pages and the answer is just a slip of paper; the assessment is early, more accurate and precise.

In our evaluation, if a student gets 60 per cent he is first class If he gets 59 per cent, he misses it No examiner could be so accurate Therefore, the present examination system must be modified introducing direct methods of evaluation

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GENERAL SCIENCE SEMINARS

R. N. RAI*

Most of our graduate teachers of science have specialised in mathematics, physics and chemistry or chemistry, botany and zoology Those who have taken the physical science group are often weak in biology and vice versa But the General Science Syllabus which they have to teach in the secondary school is a composite course containing elements of physics chemistry and mathematics as well as botany zoology, geology astronomy and other inter-disciplinary sciences It has, therefore, been found in actual experience that these teachers are somewhat inadequate to handle general science in the integrated way in which it should be dealt with

It was, therefore, decided to organize in-service training programmes for science teachers to strengthen them in those areas in which they are deficient During this year as a pilot project we decided to organize two seminars one at Dehra Dun for the northern region and another at Hyderabad for the southern region Out of 200 applicants received 60 participants were for Dehra Dun and 70 for Hyderabad, but actually 45 attended at Dehra Dun and 50 at Hyderabad.

Each Institute was in the charge of a Director who was assisted by five other teachers to deal with various areas of science The Hyderabad Seminar was arranged at the Vivekvardhini College, where we had the advantage of teachers in geology and astronomy drawn from he Osmania University The participants were also taken to Osmania Observatory for experiments in astronomy At Dehra Dun, the seminar was organized at D A V College and we drew most of the aculty from this College except for two teachers in astronomy who were invited from the Ramjas College, Delhi

The morning sessions were devoted to lectures, and the afternoons to practical work All the teachers had taken mathematics, physics and chemistry and were deficient in biology. So, we organized a large number of lectures in biology and astronomy and a ew lectures in physics and chemistry Eminent scientists were invited to give lectures and in addition, film shows were organized

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The seminars ran for a period of four weeks, but the participants felt that this period was not long enough The possibility of making the seminars during ensuing years of a longer duration, say about six to eight weeks is being considered Although biology students polled have done physics up to the intermediate stage, they still need a little more knowledge of physics in order to understand many of the new developments in the subject. It is, therefore, planned to introduce more lectures on physics in the next set of seminars. The same need was not felt in the case of chemistry

We are of the view that these seminars will certainly improve the teachers whatever may have been their quality previously.

A systematic evaluation of the result of the seminars and the benefit derived by the participants is necessary to find out how far they have been able to transmit their experience to their students. This assessment will also indicate the depth and extent of courses in the respective areas of physical and biological science that the teachers require to make them proficient to handle general science. It would be desirable and appropriate to ensure a bigger coverage of teachers so that more teachers are given this proficiency in handling general science.

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CURRENT REVOLUTION IN SCIENCE AND SCIENCE EDUCATION

D S KOTHARI

This morning's discussion has underscored three points—one that if science is done badly, it is worse than useless Good science dispels superstition, but a science taught badly not only degenerates into superstition, but makes a negative contribution to education. Therefore, if science has to be done at all, no matter at what level, it has to be done well Secondly, to learn science is to do science. There is no other way of learning science. This leads us to the experimental method The concept of experiment which is basic to science is a sophisticated concept It is intimately connected with the idea of having a conception of the scheme into which the experiment must ultimately fit, so that the student learns science by the concept of experiment This must be learnt at the beginning of the study of science, even at the school stage.

Make a Beginning in a Small Way

How are we to tackle this colossal task? We are concerned with a vast population of students. Our resources are meagre. Our teachers are very few in number and only a small proportion of them are competent But it is important that we make a good start, however modest it may be; in time it will gather its own momentum and the stream will enlarge into a reasonable dimension In order to make such a start, it is necessary that some schools in the country, carefully selected, should be allowed the freedom to experiment with this new way of learning science that is, by doing it. This is a point with which educational secretaries and educational administrators are very much concerned. The directors of summer institutes and others have also made the same suggestion of releasing a small number of selected schools from the rigidity of the present system of examination. These schools could be affiliated to the Central Board under the Ministry of Education. After a few years more schools would come under this programme and at some stage, there is bound to be a transformation in the entire syllabus and the examination system

Such a beginning is important because, we cannot tackle the problem in its entirety. The only way to tackle it is to reduce it to bits and to take up part by part and the whole process will work in a sort of chain reaction.

Scientific progress is very rapid

Now why are we concerned at all with this problem of science education? Why is every country in the world, whether it is U S A or U K, or U.S S R concerned at present with what may be called the revolution in the teaching of science? First, things connected with science directly or indirectly have been doubling during the last 10 to 15 years—the number of scientific journals, the number of scientist, even the number of road accidents depend upon the number of cars on the roads and this is connected with the progress of science and industry—all have doubled.

At the beginning of the 17th century, there were only a few scientific journals, now their number is one hundred thousand At the close of the present century, the number may be one million Science is progressing at a very rapid pace, doubling itself, overshadowing everything else. The march of science has been very rapid as compared to the progress in every other field and in a sense other areas are stationary in camparison with scientific progress Science has now become a large scale business.

[illegible] Kothari

The Nature of Science

For India, from the educational point of view, it is very important that the teaching and learning of science should somehow or other keep pace with this terrific march of science This is possible only by having almost a revolution in our way of teaching and learning science In fact, so far our learning in science has been basically the same as it was a few centuries ago, and we have been learning it in the same way as we have been learning any other subject including the classics. Now this has to change. Learning science must now be intimately connected with the broad nature of science and two points are particularly relevant here. One is that even at the elementary stage while learning science, the child must become aware that he is participating in a creative process. In fact, the great merit of science lies in the fact that it makes participation in creative work available to a large number of people It is a democratized creativity and this is a very cultural contribution of science Secondly, while dealing with science, one becomes aware that one is dealing with a growing subject. This is a subject where if ten questions are answered another hundred questions crop up for which answers have to be found. This is a big thing, it must be reflected even in the elementary school books and much more so in the high school books It is important that people should know that science is not a closed chapter and that every thing has not been necessary, that there are many questions unanswered and in fact, some of the basic questions which are still unanswered, are so simple and fundamental in their nature that even school students can be made aware of them.

Another aspect of science is that it gives a means of controlling nature In other words it give man some confidence that it is within his power to alter and improve at least his material condition This is something which is of great importance for developing countries It gives them confidence and progress. The very concept of progress lies in the awareness that man by his effort can alter his own condition and improve his lot This is relatively a new concept generated by science and this concept should, therefore, be given the widest possible difusion in a country like ours, where industrial and scientific activity is on the march.

A Revolution Needed in the Teaching of Science

To tackle this crucial problem of providing good science education, we should begin on the small scale. Even to achieve this cooperation between all the elements concerned, cooperation is necessary between schools, between universities, between education departments and government and so on We cannot rest satisfied with a little marginal improvement here and there in the textbooks or in the methods of teaching, what we want is a scientific revolution This revolution has to come and in fact has already come on us And to bring about this revolution needs great courage Let me mention just one example Before I had an occasion to go through the *PSSC Physics* book and had an opportunity to discuss it with various persons in India and in the States, I had not realised what a revolution had come about in the teaching of science. As was pointed out by an earlier speaker, many topics on sound and other familiar things, which one usually finds in the ordinary books on physics, did not find a place here The reason is this, when any special topic is described, the first question that is asked is: Why do we want to describe it? What will the student learn by it? If it will help him to do science and to think scientifically, it must certainly find a place. But if it is merely meant to describe some process, some experiment, some method which is only of transitory importance, then let us not load him with it. Most things which are described at the student level are no longer in operation anymore, and in any case would become out of date in about ten years So the emphasis must be on teaching the fundamentals of science, on teaching science as a living and growing subject and not as a dead one There is lot of dead wood in science textbooks and this has to go out to enable science being described as a growing and living thing

Concept of Equipments

The new textbook emphasizes the concept of experiments and therefore, gives importance to the laboratory To do efficient scientific teaching does not necessarily need expensive laboratory. Expensive laboratory and inefficient science teaching generally go together. Good science teaching and good science learning consist in accuracy, in trying to understand that within limitations even the crudest of equipment can be used to advantage This is far better than using first rate equipment in a third rate way. It deliberate thinking is given at the time of preparing the textbooks and the experiments to be done by students, there is no doubt whatsoever that we can afford the laboratory equipment required. A large number of experiments can be done with much less equipment than one at first sight would think possible So much can be learnt from simple everyday things provided one has learnt how to ask the right questions, to learn science by the only way of learning it, namely, by doing it

Good Textbooks Vital to Good Science Teaching

If that be the approach, one needs very little equipment to learn science properly. It may be simplest and the cheapest. But what is required is right kind of books and teachers trained in the right method of teaching science These are the three elements—/good students,/good teachers,/and good textbooks All the three are very important and perhaps the most important is good textbooks, because with a good textbooks at least good students have a chance to learn and it is impossible to get good teachers for all After all the number of good teachers in any country is always very few Most of the teachers are of average quality and this makes good textbooks extremely important.

Cooperation between schools and universities essential

It is also very important to bridge the gap between the schools and the universities In fact, this is connected with the point of co-operation which I mentioned earlier. The kind of revolution which we want to bring about can be through research by teachers in the universities and experienced teachers in schools They should get together and produce textbooks, there should be a number of alternative textbooks Some schools may select one and others may select another. Textbooks should be written by a joint team of top men, as has been done with great profit in U.S A. We can apply this to our own country and set up joint teams of specialists actively engaged in research and teachers who have contact with the young students and who know by experience the best way of bringing knowledge of young minds.

Effect Utilization of Time Basic to Good Science Teaching

Another important point related to this subject is that we should make good use of the time allotted to a given course The question of how much time we give to a course, whether two, three or four years, is also important, but it is relatively less important than making the best use of the time that is given to it. At present, in most places in our country, a student's time is very ineffectively utilized and if this is so, there is no point in lengthening the duration of the course which only means that we are wasting 3 or 4 years of the student's life So the first and foremost thing is to make the best use of whatever time that is allotted. In other words, we must do everything possible to improve the teaching of the subject.

An Operational Approach

And this brings me to the final point which was also the starting point In order that we may start tackling this problem in right earnest, we have to adopt what may be called the operational approach, namely take the first step on the right lines, then the other steps will follow in general reaction, because we are dealing with science and it is in the very nature of science that it gathers its own momentum. So we have to think of some machinery whereby some schools carefully selected could be freed from the rigidity of the present examination system. If we cannot do that, we cannot experiment, we cannot improve

We must begin with a few schools, because if we have a large number of schools in the first effort, our small resources would get dissipated over too wide a field and the results may be too meagre and unsatisfactory, and may result in what we want to achieve. When the effort proves a success in a small number of schools and the teachers have been trained, it can then be extended to a large number of schools. In order to do this we have to introduce, in our educational system, some way by which flexibility can be achieved, where it may be possible to experiment with new methods of learning and doing science. There might also be committees in the states consisting of people from the education department, teachers from the universities and from the schools which would supervise programmes of this kind and also keep in touch with what is happening in other parts of the country and in the National Council of Educational Research and Training It would be good to issue a newsletter to describe the various activities in this field. Even a teacher in a remote school, if he has some good idea or if he has thought of some good experiments which can be improvised by simple apparatus, will have an opportunity to bring his ideas and successes to the notice of a wider circle of interested persons through such a newsletter

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FUTURE PLANS

Following Dr Kothari's address, the Education Secretaries discussed the idea of having a few schools liberated from the restrictions of curriculum and examination. The discussions and suggestions made at this meeting are summarised below·

1. During the first stage at least 10 schools could be selected in each state for introducing the new approach This would give to start with, about 100-150 schools

2 There should not be any difficulty in working out the scheme. All that is needed is for the Boards of Education to formulate a suitable system of examination for the experienced schools allowing for the required flexibility. Teachers will also have to be oriented to the new project.

3 The experimental stage will be about 3 to 5 years starting from the 9th standard and increasing gradually year by year. By the end of 5 years two to three groups of students would have gone through the new project and this would give sufficient data for evaluation.

4 The project has two aspects—use of the new scientific material and the problems of examination reform. At the same time, we have also to have a research organisation which will check on the results achieved and make an objective assessment of results.

5 The project will have to be linked with the university courses The students passing out through the new methods will have to find entry into universities and professional courses, and should not be exposed to difficulty. It will, therefore, be necessary to see that this experiment is accepted by everyone concerned.

6. It will be necessary to devise the necessary syllabus for the new experimental programmes and have it examined by the boards before being introduced in the experimental schools

7. The new project should be kept under the State Education Boards, the new syllabus being treated as an alternative to the traditional one. If any state finds any practical difficulties in carrying out the experiments, the central agency should help them out.

PART FOUR

APPENDICES

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APPENDIX A

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APPENDIX B

TEXTS, REFERENCE BOOKS, EQUIPMENT AND FILMS USED IN SUMMER INSTITUTES AND HOW TO PROCURE THEM

PSSC PHYSICS PUBLICATIONS AND MATERIALS

Distributors

PSSC Teachers Guide and Resource Book PSSC Student Laboratory Manual	D C. Heath & Company 285 Colombus Avenue Boston 16, Massachusetts and Double day-Poian, New York.
Science Study Series	Wesleyan University Press, Inc Columbus, Ohio
Physics Films	Modern Learning Aids, 3 East 54th Street, New York 22, N.Y.

Science Study Series

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The Neutron Story
Magnets
Soap Bubbles
Echoes of Bats and Men
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Waves and the Ear
The Birth of a New Physics
Horns, Strings and Harmony
The Restless Atom
Michelson & the Speed of Light
The Universe at Large
Pasteur and Modern Science
The Watershed
Accelerators
Water, the Mirror of Science
The Nature of Villent Storms
Near Zero
Shape and Flow
Gravity
Life in the Universe
Rader Observes the Weather
Nerves and Muscles
The Physics of Television

Physics Films

Time and Clocks
Short Time Intervals
Measuring Large Distances
Measuring Short Distances
Measurement
Change of Scale
Straight Line Kinematics
Vectors
Vector Kinematics

Definite and Multiple Proportions
Elements, Compounds and Mixtures (in colour)
Crystals
Behavior of Gases
Introduction to Optics (in colour)
Pressure of Light
Speed of Light
Sound, Waves in Air
Forces
Inertia
Inertial Mass
Free Fall and Projective Motion
Deflecting Forces
Periodic Motion
Frames of Reference
Universal Gravitation
Elliptical Orbits
Energy and Work
Mechanical Energy and Thermal Energy
Conservation of Energy
Coulomb's Law
Millikan Experiment
Coloumb's Force Constant
Electric Fields
Electrical Lines of Force
Counting Electrical Charges in Motion
A Magnet Laboratory
Electrons in a Uniform Magnetic Field
Photo-Electric Effect
Photons
0431—Electrical Potential Energy (Part 1)
0432—Electrical Potential Energy (Part 2)
Matter and Waves
A Million in One
E.M.F.
Collision of Hard Sphere
Elastic Collision and Stored Energy
Elementary Charges and Transfer of Kinetic Energy
Rutherford Atom
Franck-Hertz Experiment
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Electromagnetic Waves
Interference of Photons
Long Time Intervals

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2500	1	Soda Straw Balance Kit
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2700	4	Hand Stroboscope Kits
2900	2	Tangent Galvanometer Kits
3100	1	Adjustable Phase Wave Generator
3200	1	Wave Demonstrator Kit

Optical Supplies including Defraction Grading	Edmund Scientific Corporation Barrington, New Jersey

BSCS BIOLOGY PUBLICATIONS AND MATERIALS

		Distributors
Biological Education in American Secondary Schools 1890-1960	$ 4.75	American Institute of Biological Sciences 2000 P Street, N.W Washington 6, D C.
Blue Version Biological Science, Molecules to Man—Text		Houghton Mifflin Company 2 Park Street, Boston 7, Massachusetts
Blue Version Students Laboratory Manual		
Blue Version Teachers Guide for Text and Laboratory Manual		
Yellow Version Biological Science		Harcourt Brace & Co., Inc 750 Third Avenue, New York 17, N.Y
Yellow Version Students Laboratory Manual		
Yellow Version Teachers Guide for Text and Laboratory Manual		
Green Version BSCS Text	$ 5 40	Education Division
Green Version Laboratory Manual	$ 1.20	Rand McNally & Company
Green Version Teachers Guide for Text and Laboratory Manual		P.O. Box 7600 Chicago 80, Illinois

BSCS Biological Techniques Series—Films

Thorne Films, 1229 University Avenue, Boulder, Colorado

Bacteriological Techniques	$60.00
Culturing Slime Mold Plasmodium	$65.00
Genetics Techniques Handling Drosophila	$40.00
Histological Techniques	$90.00
Measuring Techniques	$140.00
Neurospora Techniques	$80.00
Paper Chromatography	$140.00
Removing Frog Pituitary	$20.00
Smear and Squash Techniques	$55.00
Weighing Techniques	$80.00

EBF Biology Films

Encyclopaedia Britannica Films, Inc.
1150 Wilmette Avenue, Wilmette, Illinois

What is Ecology?
The Community
Succession—From Sand Dune to Forest
Distribution of Plants & Animals
The Temperate Deciduous Forest
The Grasslands
The Desert
The High Arctic Biome
The Tropical Rain Forest
The Cave Community
The Sea
Plankton and the Open Sea
Bacteria
Fungi
Simple Plants—The Algae
Origin of Land Plants—Liverworts and Mosses
Evolution of Vascular Plants—The Ferns
Gymnosperms
Angiosperms—The Flowering Plants
The Growth of Plants
Seed Germination
Experiments in Photosynthesis
The Single-Celled Animals—Protozoa
The First Many-Celled Animals Sponges
Stinging-Celled Animals: Coelenterates
Flatworms (Platyhelminthes)
Parasitism (Parasitic Flatworms)
Adaptive Radiation—The Mollusks
The Jointed-Legged Animals—Arthropods
Segmentation: The Annelid Worms
Social Insects: The Honeybee
Echinoderms—Sea Squirts and Their Relatives
What is a Fish?
The Fish Embryo: From Fertilization to Hatching
What is an Amphibian?
Amphibian Embryo—From Fertilization to Hatching

What is a Reptile?
What is a Bird?
The Chick Embryo From Primitive Streak to Hatching
What is a Mammal?
The Blood
Fundamentals of the Nervous System
DNA: Molecule of Heredity
Mitosis
Meiosis, Sex Cell Formation
Laws of Heredity

CHEM CHEMISTRY PUBLICATIONS AND MATERIALS

			Distributors
CBA Text—2 volume set	$3.50	per set	Chemical Bond Approach Project, Richmond, Indiana
Student's Laboratory Guide	$1 00		
Teacher's Laboratory Guide	$7.00		
Copies of Supplementary Readings for Chemical Bond Approach from Scientific American	$4 35		
Copies of Supplementary Readings for Chemical Bond Approach from Journal of Chemical Education	$2 00		Chemical Education Publication Company, 20th & Northhampton St. Easton, Pennsylvania
Set of Final Edition of CHEM Study Materials			W H. Freeman & Company CHEM Study 660 Market Street, San Francisco 4, California
Text Book Chemistry An Experimental Science	$5.80		
Laboratory Manual Chemistry: An Experimental Science	$1.60		
Teachers Guide, Guide for Chemistry: An Experimental Science	$7 00	each set	
Program Instruction Pamphlet, Use of Exponential Notation and Use of the Slide Rule	$0 50		
Laboratory Notebook	$1 00		
Eyring and Eyring—Modern Chemical Nineties	$1.95		Rinehart & Company, Inc. 232 Madison Avenue, New York 10, N Y.
Kieffer—The Mole Concept in Chemistry	$1.95		
Moeller—The Chemistry of the Lanthanides	$1 95		
Overman—Basic Concept of Nuclear Chemistry	$1.95		
Ryschkewitsch—Chemical Bonding and the Geometry of Molecules	$1 95		
Sisler—Chemistry in Non-Agueous Solvents	$1.95		
Vandwert—Acids, Base and the Chemistry of the Covalut Bond	$1.95		

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Modern Learning Aids
3 East 54 Street,
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Mechanism of an Organic Reaction
Acid-Base Indicators
Equilibrium
Molecular Spectroscopy
Ionization Energy
Gases and How They Combine
Chemical Families
Shapes and Polarities of Molecules
Catalysis
Also 16 Others are nearing completion

SMSG MATHEMATICS PUBLICATIONS AND MATERIALS

Distributors A C. Vroman, Inc 367 South Pasadena Avenue Pasadena, California, USA

Introduction to Secondary School Mathematics

Volume I, Text (ISI-IR) 2 parts	$2.00
Volume I, Commentary (CISI-IR) 2 parts	$2.00
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Junior High School Mathematics Units

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Distributors: The L.W. Singer Company, Inc. 249-259 West Erie Boulevard Syracuse 2, New York

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1.	Numbers Rational and Irrational	$0.90
2	What is Calculus About?	$0.90
3.	An Introduction to Inequalities	$0.90
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5. The Contest Problem Book	$0.90
6. The Lore of Large Numbers	$0.90
7. Uses of Infinity	$0.90
8. Geometric Transformations	$0.90
set of eight titles	$7 20 per set

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Books Available in India

PSSC Physics Text	Rs 8.00 Rs. 2.00 (Postage)	Chief Publication Officer National Council of Educational Research and Training, 114 Sundernagar New Delhi-11
General Science Syllabus (Grades I-VIII)	Rs 2 25 (Plus Postage)	

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APPENDIX C

EQUIPMENT, SPECIMENS AND CHEMICALS REQUIRED FOR BSCS YELLOW VERSION LABORATORY

Page. No.	Ex. No.	Exercise	Glassware etc.	Chemicals	Specimens
21	4	cells as seen by Hooke	razor blade microscope	dettol	cork
25	5	living plant cells (Onion)	filter paper needle glass slide microscope	iodine solution (staining)	onion
29	6	living plant cells (Tradescantia stamen hairs)	Microscope glass slide 1		Flowering *Tradescantia*
31	7	living plant cells with Chloroplasts	microscope finger bowl		Anacharis Elodea) aquatic flowering plant Hydrella
33	8	varieties of plant cells (a) store cells.	microscope		(1) nut shells, cherry pits, or preach "stores" (2) slides of stone cells.
,,	,,	(b) wood cells	slide & cover slip paper towel (filter paper).	phloroglucinol solution.	fine board. slide pine wood
34	,,	(c) cotton fibres	microscope Petri dish Cotton boll cellulose sponge	zinc-chloride solution, iodine potassium-iodide solution	cotton
37	9	animal cells	toothpick	methylene blue stain physiological salt solution.	(1) loose epidermal cells from inside of cheek. (2) Skin cells (3) blood cells (4) striated muscles. (5) Frog's bucal cells. (6) sperm cells from testing frog.

Page No.	Ex. No.	Exercise	Glassware etc.	Chemical	Specimens
41	10	Living single-celled organisms	microscope fictures of micro-organisms slides & cover slips	0.85% salt solution	(1) pond water (2) frog's intestine to get protozoans from their (*Opalina* & *Nyctotherus*)
51	12		Petri plate having nutrient agar Microscope needle Bunsen burner, Glass rod.	aceticacid	culture of slime mold, *Physarum polycephalum*
55	13	Diffusion through a membrane	Bunsen burner rubber bands clinitest tablets or tes-tape. 3/8 inch cellophane (2 pieces 8″ long) 2 bottles 3 test tubes test-tube holder 1 c.c. pipette.	80% glucose solution soluble starch Iodine solution Benedicts solution.	
61	14	Activities of the Cell membrane	Test-tubes test-tube racks microscope	Congo-rde solution 10% Formalin 5% Nack	5 c.c. suspension of yeast cells (for each group) Spring of *Anacharis*.
67	16	The detection of some specific compounds in cells	Microscope slides Bunsen burner Razor blade	Iodine solution Benedicts solution	Potato Apple or other fruit
71	17	Conversion of polypaccharides to monobaccharides by acid hydrolysis	6 test tubes (per student) cotton cloth water bath	1.0% starch solution 2N H2 SO4 2NNa OH4 Benedict's solution (*or* Fehling's solution A & B)	
75	18	Enzymes in living tissues. (a) in various tissues	(for 2 students) 2 test tubes Test-tube holder Beaker Funnel Bunsen burner filter paper Mortar and pestle	Hydrogen peroxide	*tissues*: potato Fly, worm. etc,

Page No.	Ex. No.	Exercise	Glassware etc.	Chemical	Specimens
		(b)in corn grains (demonstion)	4 petrid ishes rajor blade	starch agar plain plain agar Iodine solution	soaked Corn grains soaked grains killed in FQAA
79	19	Enzyme action on a protein	2 test tubes corks. No 1 Whatman Charmatogarphy paper Scotch tape. Pipette	Ninhydrin *Solvent*- butanoli acetic acid: eater (4:1:1). Toluence.	*Test I mixture* hard boiled egg white (2 pieces of 2mm tube); 10 c c. pineapple juice, 3 drops tolune. *Test II mixture* Same as in I but pineapple juice boiled for 3 to 5 minutes before use.
85	20	Factors influencing enzyme action	Bunsen burner (For a team of 5 students) 7 test tubes 2 test tube holders Test tube rack Funnel, Filter paper. Thermometer 500 c.c. beaker watch-glass, 1. c c. pipette, wax pencil, 10. c.c . graduated cylinder	Iodine solution Benedicts or Fehling's solution. 0.1N NaoH 0 1N Hcl. Paraffin starch solution. Ice.	Soda crackers or Saliva. Fehling's solution
91	21	An introduction to photosynthesis and respiration (a) Relations between photosynthesis & res-	(For a group of 7) 7 100 c.c. beakers 7 15x125mm.test tubes. Filter paper disk pa-	Sugar solution. NaOH pellets Aluminium foil.	7 flies 4 green, leafy 7 cockroaches green, leafy shoots about 75mm. long.

Page No.	Ex No	Exercise	Glassware etc.	Chemicals	Specimens
		piration	per millimeter ruler, marking pencil Graduated cylinder 100 c.c.		
		(b) Effect of light on O2 production during photosynthesis	Drawing a graph (Demonstration)		
		(c) Comparison of aerobic & anaerobic respiration	3 gas collection bottles (8 ox.) 32 hole rubber stoppers 2 gallon jarx 3 test-tubes test tube holder 1 c.c pipette Aquarium aerator 2 glass tubings 8" long. 3 bent glass tubes 2 small funnels 3 rubber tubing (foot long) Burner, 500 c.c. graduated cylinder 2200 c c cylinders, spatula, 2 pieces aluminium foil. Flask brush.	lime water (4 liters) Benedict's or Fehling's solution Mineral oil Methylene-blue solution Bromothymol-blue solution 1 litre of water acidified with 10 c. c. conc. Hcl	Applecider 1(100 c.c.) Active, dry yeast.
109	22	Cell division (a) cell multiplication unicellular organisms	Microscope Wide-mouthed bottle	Methylene-blue stain	Yeast (Wet or dry) Molasses
		(b) Cell division in multicellular organisms	microscope		onion root
113	23	Mitosis in plant and animal cells. (a) Smears of developing *Tradescantia* pollen	microscope razor blade Forceps dissecting needle slide & cover slips Millimetre ruler paper towel	Aceto-carmine solution	*Tradescantia* flaver buds

Page No	Ex. No.	Exercise	Glass, wire etc.	Chemicals	Specimens
		(b) Nuclear and cell division in onion root tips (c) Smears of onion root tips (d) Animal cells in mitosis	microscope microscope		prepared slide of onion root tip, slide of *Ascaris or* white fish eggs
123	25	Early experiments in spontaneous generation	7 flasks (250 c c) glass tube (7-8 mm diam) C-shaped glass tube S-shaped glass tube 5 cork stoppers for flasks 3 stoppers with holes	Sealing wax *or* paraffin	500 c c. nutrient broth or beef bouillon
127	26	A garden of micro-organisms	Filter paper. Ten 12-14 inch glass finger bowls *or* plastic containers Glass marking pencil Glass covers for finger bowls microscope adhesive tape		Rotting fruits (orange, tomato etc) Grapes, moldy bread, pond, lake, river water with decaying material Cottage cheese Hay, dried beans. Rich soil 20 gms. peppercorns Squash *or* Pumpkin cornstarch
141	27	Microscopic appearance of molds	Scotch tape 5 petri dishes Sabourand's (Sterile) Stereomicroscope medium wax *or* paraffin Bunsen burner Thermometer Balance. Filter paper		(*or* potato dextrose agar) Glycerin *or* 30% alcohol Culture of micro-organisms Fron exercise number 26,

Page No.	Ex No.	Exercise	Glass ware etc	Chemicals	Specimens
149	28	Microscopic appearance of yeasts	Microscope	Congo-red stain Active dry yeast (cake) compressed yeast (package) Methylene-blue stain.	Fermenting apple cidar Crushed grapes Peppercorn infusion (a few days old)
153	29	Microscopic appearance of bacteria	Glass tumbler Paper towel. Compound microscope with oil immersion objective Immersion oil. slides & cover slips.	Crystal-violet stain	
159	30	How to get pure cultures of micro-organisms	*Culturing micro organisms.* (For a group of 10 students 2 wire test-tube baskets. water bath 2 to 5 bacteriological loops 1 litre flask. 40 test-tubes-100x18 mm 25 petri plates 500 c.c graduated cylinder 5 100 c c pipettes.		400 c c. nutrient agar or beez bouillon agar. Soil suspension (1 gm garden soil in 5 c c. water) Hay infusion. Mixed suspension of *Escherichia coli* and *Sarcina lutea* pepper water Stagnant pond water.
The distribution of micro organisms					
171	31	Air-borne microbes	10 sterile petri dishes water bath		10 tubes with 150 c c sterile nutrient agar. One tube agar nutrient.
175	32	Microbial imprints (a) *For transfer technique*	Roll of scotch tape ½" wide. 1 sterile petri dish water bath Thermometer		

Page. No.	Ex. No.	Exercise	Glass ware etc	Chemicals	Specimens
		(b) *For contact dish technique*	1 clean petri dish, 1 3-cork stopper. Filter paper rubber cement (plastecene) waterbath. Thermometer.		2 plastic jelly dishes 40 c.c. nutrient agar in flask.
181	33	Intimate microbes	Tooth pick Microscope with oil immersion objective Immersion oil.	Crystal violet stain.	
185	33	Growing microbes from skin and saliva	1 sterile petri dish 1 sterile cotton swab slide & coverslips.		1 tube sugar nutrient agar.
189	34	Microbial "fall out"	12 sterile petri dishes 1 12-inch finger bowl. (For 3 students)		Moldy fruit, vegetable or bread. 12 tubes sugar nutrient agar.
193	35	Microbial distributors	3 sterile petri dishes Water bath. Thermometer		3 tubes of nutrient agar one small bottle with house fly or cockroach. Hay infusion *or* broth culture of *Sarcina lutea.*
197	36	Microbial tracers	(For 8 students) 8 sterile petri dishes.		(1) 8 tubes-nutrient agar (2) 7 pieces hard candy, dipped in water to make them sticky, in separate dishes. (3) one piece of hard candy, immersed in a culture of yellow pigmented bacteria in a dish.

Page No	Ex No	Exercise	Glass ware etc	Chemicals	Specimens
203	37	Effects of temperature on micro-organisms.	12 sterile plugged test tubes		Raw skim milk (or pasteurized skim milk to which 1% butter has been added)
207	38	Oxygen and growth of microbes	2 sterile-nutrient agar (Sabourand's) slants, one in a screw-cap test tube on vial, or in a test tube with tight-fitting rubber stopper The other tube should have a cotton plug.		(1) Broth culture of the bacterium *Serratia marcescens*. (2) Sporulating mold from *exercise*. 26.
211	39	Effects of othalinity and acidity on micro-organisms	35 test-tubes 150 × 18mm. Hydrion paper (pH paper) Test tube racks	300 c c of lucose (or sucrose) nutrient broth 400 c.c. nutrient broth O. IN Hcl O IN Nao H 5	Broth cultures of bacteria, yeast & mold
217	40	Effects of pH reaction on sterilization by heat.	20 sterile petri dishes.	tubes of nutrient broth. pH 3. 0, 5 0,7 0,9 0,11 0 20 tubes nutrient agar.	Nutrient broth culture of *Serratia maccesens*.
221	41	Water content and microbial growth.	12 test tubes Plugging cotton	..	Fresh & dried apples, peaches, apricots, beans, peas or raisins
223	42	Food preservatives & micro-organisms	Sterile test tubes Graduated cylinder	Spices Sodium benzeate Sugar Salt	Ground beef Milk
225	43	Effect of Chemicals on microorganisms.	Sterile cotton swabs Sterile test tubes Tubes of sterile water.	4 chemical solutions such as clorox, lysol, Phenol, iodine, Zephiran Clove oil. Merthiolate, 4 mouth wastes such as listerine, lavoris, Cepacol Astringasol Hydrogen peroxide, Micrin,	One nutrient agar petri plate for 2 students.

Page No	Ex No.	Exercise	Glass ware etc.	Chemicals	Specimens
229	44	Effects of antibiotics on bacteria.		Antibiotic disks such as penicillin, Streptomycin, aureomycin, terramycin	Broth cultures of *Staphylococcus* albus and *Escherichia coli.* Nutrient agar plates
235	45	Digestion of foods by microbes (a) Starch digestion.	Sterile petri dishes	Dilute iodine solution (1 part Gram's iodine to 8 parts water)	400 c.c. sterile nutrient agar containing 0 2% starch. Hay infusion yeast suspension few grains of dry yeast in water with enough syrup to colour
		(b) protein digestion	Petri plates.		Mold suspension Skim milk Hay infusion or *B. Subtilis* Tubes of nutrient agar.
239	46	Fermentation of sugars by yeast and bacteria	30 Durham Fermentation tubes 5 1. c.c.	Nutrient broth with 1% glucose (300 c.c) 300 c.c bromthymol blue 0 04% solution in alcohol Nutrient broth with 1% lactose	(1) Yeast suspension or few grains of dry yeast (2) Broth culture of bacteria (*Escherichia coli, staphylococcus albus* or soil-suspension may be used).
243	47	Nodule-forming bacteria *Part A.*	2 dissecting needles microscope	India Ink or Methylene blue.	(1) Legume plants
		Part B	(1) 5 inch flower pots with saucers (2) Washed sand (3) Test tube	(1) Zonite or other fungicide (1 : 10 dilution) (2) Distilled water.	(1) Commercial (2) *Rhizobium* inoculum Legume seeds. (3) Nodules from roots of legumes (4) Nitrogen free nutrient

Page No.	Ex No	Exercise	Glass ware etc	Chemicals	Specimens
		Part B (alternative)	(1) 4 sterile test-tubes	Distilled water	(2) N-free agar (2) Commercial *Rhizobium* (3) Legume seeds (4) Nodules from roots of legume.
247	48	Microorganisms and infectious disease	(For 2 students) 2 sterile petri dishes 3 finger bowls 3 glass covers water bath Thermometer 500 c c. beaker perforated cooking spoon.	2 tubes of Sabourands medium or potato-dextrose agar 70% alcohol Household disinfectant (eg Chlorox)	1 Molding fruit. 2. Perfect fruits.
255	49	Microbial antagonism or antibiosis (a) Detecting antibiosis in a mixed soil population by the "crowded plate" technique	(1) Balance (2) Weighting papers (3) Water bath (4) Gas burner (5) Thermometer 1 c c pipette (7) 2 sterile petri dishes	(For 2 students) (1) tube with 10 c c. water (2) tubes of glucose agar (3) 2 glucose-agar slants.	(1) soil sample.
		(B) Antibiosis with pure cultures of the giant colony-streak plate technique.	(1) 2 sterile petri dishes. (2) Water bath (3) Gas burner. (4) Thermometer	2 tubes of glucose agar	(1) Agar slant Culture of soil antibiotic (from Part A) (2) Agar-slant culture of an actinomycete (*Streptomyces grisens*) (3) Broth cultures of test organisms (1-2 days old) (a) *Bacillus subtilis* (b) *Escherichia coli*. (c) *Micrococcus flavus*. (d) *Serratia sp.*

Page. No.	Ex No.	Exercise	Glass ware etc.	Chemicals	Specimens
265	50	Bacterial populations in milk	4 test tubes for each team of students) water bath (For 2 students)	Methylene-blue solution 1 30, *or* Methylene-blue thiocyanate tablets.	Old and fresh samples of raw and pasteurized milk
269	51	Testing water for pollution	(1) 1 small bottle (Sterilized by boiling) (2) 5 sterile petri dishes (3) 2 sterile 1 c.c pipettes (4) Water bath (5) Thermometer	(1) 5 tubes of nutrient agar, 15 c c. (2) 4 tubes 1% lactose agar (or 2 lactose broth fermentation tubes).	
6.3.1	6.3	Variety in the Animal kingdom Hydra and planaria	(1) Stereomicroscope (2) Watch glasses (3) Red or black wax pencil (4) Dissecting needle (5) Prepared slides of Hydra and planaria	(1) Stock acquaria water	(1) Green Hydra (2) Planaria. (3) Protozoan culture small or crustaccanu (4) Raw liver
6.4.1	6.4	Ascaris and Earthworm	(1) Hand lens (2) Stereomicroscope (3) Pencil (4) Dissecting tools (5) Pins (6) Pen flash light (7) Camel's hair brush (8) Watch glass	(1) Vinegar 10% Hcl. (2) Water	(1) Reserved Ascaris (2) Live earthworms
6.5.1	6.5	Cray fish and Grasshopper	(1) Dish (2) Dropper (3) Stereomicroscope (4) Dissecting needles	(1) Clear water (2) Ink	(1) Grasshopers (immature and adult) (2) Cray fishes (live and preserved)

Page No	Ex No	Exercise	Glass ware etc.	Chemicals	Specimens
6.6 1	6 6	A comparative study of multicellular animals The Frog and the rat	(1) Box (2) Pen flash light		(1) Frog's (live and preserved) (2) Rats (live and preserved) (3) Frog skeleton (4) Rat skeleton
6.7 1	6 7	Nematodes in soil from our own gardens	(1) 1 Glass funnel (2) Rubber tube (3) Clamp or stop cock (4) Plastic bag. (5) 1 Microscope (6) Clean microscope slides. (7) cover glasses		(1) Scottie tissues (or other tissues that do not disintegrate rapidly when wet)
7 1.1	7.1	Diversity of plants Score card for comparison of 2 or more kinds of plants			Selected native plants
7.2 1	7.2	A field and Laboratory study of variation in plants			Various forms of selected plan groups
7.4.1	7.4	Spirogyra and oedogoniums Two filamentous algae	Slides and cover glasses Microscope	Iodine solution Indian ink culture media (optional)	Cultures of spirogyra and oedogenium
7.5 1	7.5	Comparison of a fungus and a lichen	Glass slides Forceps. Probes and needles Terrarium or large mouth jars Stress and compound microscopes	Glycerol	Mushrooms and lichens
7 6 1	7.6	Mosses and Liver worts			
7.7 1	7.7	Ferns and Hors starts	Four flower pots Four clay saucers white paper Four pieces of	(1) Kroop's solution (Mg So_4-0 259 $Ca(No\ 3)_2$-1.00	Fern plants with spore cases. Horse tail plants with spore bodies

Page No.	Ex. No.	Exercise	Glass ware etc	Chemicals	Specimens
			soft clothes line ropes 25 cm. long A glass slide for each person. Cover slips Petri dish per person. Compound or Stereomicroscope	KH_2Po_4-0.25 kol-0 128. Fecl$_3$ (1.0% sol) 10 drops. Distilled water 1000 ml) (2) Potassium permanganat (KMMo$_4$)0 01% sol. (3) 20g. agar (4) small candles (5) 500 ml. of sterile distilled water	
7.8.1	7 8	The Reproductive life history of the pine	(1) Stereomicroscope (2) Compound microscope (3) Slides (4) Cover slips (5) Forceps (6) Teasing needles (7) Dropper (8) Bunsen burner (9) Prepared slides	(1) Acetocarmine (2) Water	(1) Pine branches with cores
8.1.1	8.1	Genetics. Heredity and environment	(1) 4 culture (Petri dishes or finger bowls) (2) Filter paper or blotting paper cut to fit bottom of dishes. (3) 2 covers for dishes opaque (cut down milk cartons, tin cans or card board boxes) which should fit smoothly against the table top		

Page No.	Ex No.	Exercise	Glass ware etc	Chemicals	Specimens
8.2.1	8.2	Mitosis	(1) Pipe-cleaners of two colours (2) Beads pierced to accommodate 2 pipe cleaners (3) Scissors or (4) Poppit beads (about 40) of 2 colours (5) Floral wire or soft metal tape		
8.4.1	8.4	The induction of polyploidy in plant cells	(1) Pyrex watch glasses (2) Glass beakers (3) Paper towels (4) Compound microscope (5) Glass slide and cover slip (6) Razor blade (7) Bunsen burner (8) Ring stand and ring clamp	(1) Acetocarmine stain (2) Colchicine	Onion sets or bulbs.
8.6.1	8.6	Distinguishing of ♂ and ♀ Drosophila adults	(1) binocular stereoscopic microscope or a good hand lens. (2) An etheriser (3) A small tapered water colour brush or a bent tip dissecting needle 4. A plate such as a white plastic square of bathroom tile (10 cm or 4 inches square) or a piece of porcelain glass (a piece of plain glass with a		

Page No.	Ex. No	Exercise	Glass ware etc	Chemicals	Specimens
			white card fastened underneath will also serve (5)A morgine		
8.7.1	8.7	A cross between 2 different genetic strains of Drosophila	(1) Glass marking pencils or "Labelon" (a type of stick-on tape, with a coloured border and white centre which can be written on with a pencil) (2) Two cultures vials for each team of 2 students (3) Equipments used in previous exp for handling and examining Drosophila		(1) Cultures of 2 different stocks of Drosophila about 14 days old.
8.7.7	8.7	The results of crossing the F individuals	(1) Culture bottles of vials containing F_1 generation flies (2) Two fresh culture bottles or vials for each team of 2 (3) Same equipment as previous exercise		
8.8.1	8.8	The test cross	(1) Two fresh culture vessals for each team (2) Same equipment as previous exercise		(1) A vial of virgin showing the wild type phenotype and possibly carrying some marked recessive gene. (2) A culture of

Page No.	Ex No	Exercise	Glass ware etc.	Chemicals	Specimens
					flies showing a trait determined by a recessive gene (such as dumpy ebony or sepia)
8.9 1	8 9	Independent inheritance	Two fresh cultures vials or bottles for the initial cross two more for the cross of F. flies Other equipment as in the pregoing exercises		(1) Virgin of one type and of the appropriate type one of the following (a) Dumpy virgin and ebony (b) Ebony virgin and dumpy (c) Dumpy ebony virgin and wild type (d) wild type virgin and dumpy ebony males.
8 10.1	8.10	Linkage and crossing over	4 fresh culture vials or bottles for each team. Other equipment as in the pregoing exercises		(1) Stock cultures of (a) wild type (×) (b) Sepia spinedlers or black vertigial (c) Sepia nonspinders or non black vertigial (d) Non-sepia spineders or non-black vertigial
8.11.1	8 11	Sex-linkage inheritance	4 fresh cultures vials or bottles. Other equipment as in the foregoing experiments		Drosophila stocks of wild type and white eye colour
8.13 1	8.13	Neurospora The procedure	(1) Sterile agar slants of "complete	50% solution of Commercial	(10 Culture of Neurospora Ci-

Page No	Ex. No.	Exercise	Glass ware etc.	Chemicals	Specimens
		used by geneticists for crossing strains	Neurospora medium (a) 1 Large (2.5 × 17.5cm)tube (b) 8 small tubes 16 small (2 × 8 cm) tubes (for part IV) (2) Very thin glass teasing needles (3) Petri plate of plain agar 4%	Putes or clorose	assa wild type, strain "A" (2) Culture of Neurospora crassa albino type strain "A"
8.14.1	8.14	Neurospora Detecting nutritionally deficient strains			1. Five tubes of sterile "minimal" Neurospora medium for each group of 3 or 4 students 2 Five tubes of sterile agar slants of "complete" Neurospora medium 3 A culture of wild type Neurospora crassa 4 Cultures of three known biochemically deficient strains of Neurospora crassa
8.15 1	8 15	Neurospora: Demonstrating the nature of Nutritional deficiency in a mutant.	(1) 5 sterile tubes of minimal medium (liquid) (2) One tube of sterile water medicine droppers	(1) Commercial thiamine cublets 100 mg. (2) 2 % yeast medicine extract solution	(1) Culture of Neurospora crassa wild type. 2 Culture of N. Crassa Thiamine deficient mutant 3. Three sterile agar slants of complete medium

Page No.	Ex No.	Exercise	Glass ware etc.	Chemicals	Specimens
8 15.7	8.16	General differences in peas	(1) Two small bottles (2) Microslides (3) Razor blade or scalpel (4) Compound microscope (5) Mortar and Pestle (6) Two 250 ml. beakers (7) 2 medicine droppers (8) Balance	(1) 1 disk of glucose agar (2) 300 ml distilled water (3) Iodine solution for starch tests	(1) Peas of the genetic strains "round and wrinkled"

APPENDIX D

PARTICIPANTS

List of Names and Addresses of Participants who attended the Summer Science Institutes 1963

Name and Address	Institute
Andhra Pradesh	
1. Barnabas, Miss Essica Methodist Boys School Hyderabad	Biology
2. Kamalakantham, T. S. Town Government Modern High School Kurnool	Physics
3. Khandelwal, Shyam Narayan Secunderabad Hindi Vidyalaya Secunderabad	Mathematics
4. Pillai, D Yelumalai S. V Higher Secondary School Tirupati	Chemistry
5. Sarma, N S. Ramakrishna Gandhiji Municipal Higher Secondary School Vijaywada	Mathematics
6. Subba Rao, D Government Multipurpose High School Mahboobnagar	Chemistry
7. Subramanyam, T. B. V Senior Master Hyderabad Public School Begumpet, Hyderabad	Physics
8. Venkataratnam, V. Assistant Master Government Multipurpose High School Mahboobnagar	Physics
9. Virginia, Miss Rajah State Girls High School Guntur	Biology

Assam

1	Barman, Upendra Nath Government Higher Secondary School Dhubri	Mathematics
2	Das, Mrs Hemprabha South Amolapethy P.O Rehabari Dibrugarh	Biology
3	Goswami, S. P O Gauripur Nareswar Tal	Biology
4	Roy, Rabi Bhushan Government Higher Secondary School Silchar	Physics

Bihar

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3	Pathak, Ram Paras R R Higher Secondary School P.O Surajpura Dist. Shahabad	Mathematics
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9.	Gupta, Abhai Ram 127 New Rajendra Nagar New Delhi	Physics
10.	Gupta, Vijay Kumar Government Higher Secondary School Meharauli	Physics
11.	Jain, Abhay Kumar Government Girls Higher Secondary School Roop Nagar Delhi	Mathematics
12	Mathur, Miss Kusum Government Girls Higher Secondary School Roop Nagar Delhi	Biology
13.	Mohta, R K. Sardar Patel Vidyalaya Lodi Estate New Delhi	Biology
14	Pathik Jag Dev Gupta Ramjas Higher Secondary School No. 5 Karol Bagh New Delhi	Mathematics
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16.	Ratnam, Ved M C Higher Secondary School Rouse Avenue New Delhi	Physics
17.	Sharma, Miss Santosh Government Girls Higher Secondary School Jama Masjid Delhi	Chemistry
18.	Singh, B. P. 3315, Kucha Jalal Bukhari Darya Ganj Delhi	Biology

19. Tandon, R. L. B-21, West Patel Nagar New Delhi	Biology
20. Tanwar, Budh Singh Government Boys Higher Secondary School Shakti Nagar Delhi	Physics
21. Upreti, Bepin Chandra Government Boys Higher Secondary School Kalkaji New Delhi	Physics

Gujarat

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2 Anjaria, M. J. C/o Mr. J. H. Anjaria Near Jubilee Gardens Opposite P.T.I Rajkot	Physics
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4. Kansara, J. C. N. M. Nootan Sewa Vidyalaya Visnagar	Chemistry
5. Parekh, Miss Vasu R. 35 Government Society Ahmedabad	Biology
6. Patel, I. N. N. M. Nootan Sewa Vidyalaya Visnagar	Physics
7. Pathak, Chandra Prasad R. Principal Swastik High School Pankorenaka Ahmedabad	Physics
8. Sutaria, N. Shree Vidyanagar High School Usmanpura Ahmedabad	Biology

Kerala

1.	Amma, Mrs. Thankamoni N.S S Model High School Perunnai Changanacherry	Biology
2.	Das, V. Kumara Kanjiramkulam High School Nellickakuzhi Neyyattinkara	Biology
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5.	Marykutty, Miss M Joseph S.H G Higher Secondary School Bharananganam	Biology
6.	Nayar, K. Krishnan Science Assistant High School Parassala	Physics
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8.	Pillai, Sridharan Model School Trivandrum	Chemistry
8.	Rajaratnam, P K. Government High School Peringottukara	Mathematics
9.	Thampi, S. Prabhakaran T.C. 652 Kutticand Manacand Trivandrum-9	Biology
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2	Dubey, B. K Maharajwada Multipurpose Higher Secondary School Ujjain	Biology
3	Jain S N. Government Hamidia Boys Higher Secondary School Bhopal	Mathematics
4	Kalra, Jagan Nath Gorkhi Higher Secondary School Lashkar (Gwalior)	Mathematics
5	Kapshe, V. K Lecturer Government Boys Higher Secondary School Rajgarh	Physics
6.	Kawadkar, N. K. Lokamanya Tilak Higher Secondary Multipurpose School Chanda	Mathematics
7.	Khan, M. M. Government Higher Secondary School Dongargarh	Physics
8	Mohdiwale, C. N. 'Dehanker's Bada' Tilaknagar Bilaspur	Biology
9.	Nandekar, G. S. Government Girls Higher Secondary School Sarala Ujjain	Mathematics
10,	Khwaja, Nasiruddin Secondary School Ichhawar	Chemistry
11.	Porwal, Laxmi Narain Maharajwada Multipurpose Higher Secondary School Ujjain	Mathematics

12	Rana, K S Government Higher Secondary School Nai Sarai District Guna	Chemistry
13	Rastogi, V S. 68/13 South T T. Nagar Bhopal	Biology
14.	Sachan, M L. Government Higher Secondary School Sironj	Chemistry
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16	Telang, S R Higher Secondary School Sector VII Bhilai	Chemistry
17	Thakur, N. S. Lecturer Government Multipurpose Higher Secondary School Balaghat	Physics

Madras

1.	Bhashyakaracharyulu, S. K. M R.M P School Vizianagram	Chemistry
2.	Nair, D Gopalakrishnan Naval High School Cochin	Chemistry
3.	Rajan, M S. Sri Ranga V M High School Bodinayakanur District Madurai	Mathematics
4	Subramanian, K. Science Assistant Board High School Kadayanallur	Physics

Maharashtra

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3. Choudhari, D. D Shendar's Building Near Irwin Hospital Amravati	Physics
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6. Dixit, G. Y. Tilak College of Education Poona	Chemistry
7. Ghanpurey, Miss S. B. Chikitsak Samuha S. H. School Girgaum Bombay	Chemistry
8. Ghodke, Vasant Shri Shivaji S. S. High School Yeotmal	Chemistry
9. Gokhale, S. S Manibai Gujarathi Multipurpose High School Amravati	Chemistry
10. Gurjar, Miss D. G Government Girls Multipurpose Higher Secondary School Akola	Mathematics
11. Inamdar, P. L. Nutan Vidyalaya Multipurpose High School Sailu (Parbhani)	Chemistry
12. Kapadekar, P. K. Mahila Vidyalaya Higher Secondary School Belgaum	Physics
13. Kelkar, C. V. 69 Shaniwar Peth Satara	Physics

14.	Kelkar, D. V Govindrao High School Ichalkaranji	Chemistry
15.	Kulkarni, D V. Principal Raosaheb Rupchand Vidyalaya Jalgaon	Mathematics
16.	Kulkarni, V. V. Dayanamata Vidyalaya Sangamner	Chemistry
17	Mehta, M F. Govindas High School Ichalkaranji	Mathematics
18	Puri, S M. Shri Shivaji S S High School Yeotmal	Chemistry
19	Sathaye, M. V. Vidya Mandir Brahmanpuri Miraj, Sangli	Physics

Mysore

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5.	Ramachandra, C. S. Nuthana Vidyalaya High School Gulbarga	Mathematics
6.	Rao, K. Sreepada Municipal High School Bellary	Physics

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8	Venkatramaih, K. Shri Siddaganga High School Tumkur	Chemistry

Orissa

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3	Mishra, Harihara R.C. Higher Secondary School Cuttack	Physics
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5.	Panda, Karunakar Capital High School Unit III Bhubaneswar District Puri	Mathematics

Punjab

1.	Kathpalia, K. K. Government Higher Secondary School Rohtak	Mathematics
2.	Singh, Harbans C/o Government Higher Secondary School Garhshankar District Hoshiarpur	Biology
3.	Varma, G. S. 8 Civil Line Delhi Road Rohtak	Biology
4.	Verma, Bal Krishna Government Higher Secondary School Narnaul	Chemistry

Rajasthan

1 Agarwal, R L M P Higher Secondary School Chittorgarh	Chemistry
2. Bhardwaj, P.N. 7 B Block Ganganagar	Biology
3 Gupta, M K. Government Multipurpose Higher Secondary School Deoli	Chemistry
4. Gupta, Rajendra Government Multipurpose Higher Secondary School Ajmer	Mathematics
5 Joshi, Brij Gopal Government Multipurpose Higher Secondary School Sri Ganganagar	Mathematics
6 Katariya, S K. G.M.P Higher Secondary School Nathdwara	Chemistry
7. Kulshrestha, Bhuvnesh Chandra Vijanand Higher Secondary School Ajmer	Mathematics
8. Singh, Shivnam C/o Mr. Hari Singh General Hospital Bikaner	Biology
9. Suri, Kuldeep Singh Government Multipurpose School Sri Ganganagar	Chemistry
10. Tikkiwal, Shanti Swaroop Government Jawahar Higher Secondary School Ajmer	Mathematics
11. Vijay, Jagdish Government Multipurpose Higher Secondary School Nayapura Kota	Physics

Uttar Pradesh

1. Agrawal, Anant Ram Assistant Master Government Inter College Saharanpur	Physics

2	Bannerjee, Amullya Dhar Government Central Pedagogical Institute Allahabad	Mathematics
3	Dayal, Rameshwar Assistant Master Government Inter College Fatehgarh	Physics
4.	Gupta, Ram Krishna B N V Inter College Rath	Chemistry
5	Gupta, S. C. Government Inter College Hastinapur (Meerut)	Chemistry
6.	Gupta, Miss Sushma C/o Mr B K Gupta Superintending Engineer (Irrigation) Agra	Biology
7	Khanna, Brij Krishna Assistant Master Government Inter College Amroha	Physics
8	Kulshreshtha, K S. Government Inter College Etah	Biology
9,	Kulshrestha, P. S. Kishori Raman Intermediate College Mathura	Mathematics
10	Mehta, D. P. Jwalapur Inter College Jwalapur	Mathematics
11.	Pande, M N. Government Inter College Jhansi	Physics
12	Saxena, Kavindra Nath Government Inter College Moradabad	Mathematics
13,	Sharma, Ravi Dutt Government Jubilee Inter College Lucknow	Mathematics

14.	Singh, Mahipal Assistant Master, Government Jubilee Inter College Lucknow	Physics
15.	Srivastava, V M S. Assistant Master Government Inter College Kanpur	Biology

West Bengal

1.	Banerjee, J S. South Point Higher School 16 Mandeville Gardens Calcutta	Physics
2.	Bhattacharya, Pramatha Nath Hijli High School Madnapur	Physics
3.	Choudhury, A.C D. 350/1 Prince Anwarshah Road Calcutta	Biology
4	Khannah, B P.S. 146/12 Lake Gardens Calcutta	Biology
5.	Mitra, Ashok Kumar Shri Ram Higher Secondary Multipurpose School Abinashpur	Physics
6	Modak, Hrishikesh Das Christian Collegiate (Higher Secondary and Multipurpose) School P.O. and Dist. Bankura	Mathematics
7.	Roy, Bhupesh South Point High School Calcutta	Chemistry
8	Singh, Ram S Hindi High School 1 Moria St Calcutta	Chemistry
9.	Sur, Mrs. Sandhya 15-B. N.N. Ghosh Lane Tollyganj Calcutta	Biology